使 用 说 明 书
OPERATION MANUAL

ST16 型 示 波 器
OSCILLOSCOPE MODEL ST16

中 华 人 民 共 和 国
上 海 无 线 电 二 十 一 厂
SHANGHAI 21ST RADIO WORKS
THE PEOPLE'S REPUBLIC OF CHINA

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ST16 型 示 波 器

ST16 型示波器为一通用的小型示波器，它具有 0～5MHz 的频带宽度和 20mv/div 的垂直输入灵敏度，扫描时基系统采用触发扫描，最快扫速达 100ns/div。ST16 型示波器具有体积小、重量轻、耗电省、造型新颖、操作携带方便等特点。仪器内附 100mv 校准信号装置，可供垂直灵敏度和水平时基扫速校准之用，对被测信号能满足定性定量要求。因此 ST16 型示波器非但能适用于一般脉冲参量的测量，特别对电视机、音频放大器、收音机等电子设备的维修调试十分方便，可供生产线使用。此外亦可作为程序控制机床等机械设备的监视器。

一、技 术 性 能

垂直系统：

频 带 宽 度：DC DC～5MHz 3dB

DC～10MHz 6dB

AC 10Hz～5MHz 3dB

10Hz～10MHz 6dB

输入灵敏度： 1. 20mv/div～10v/div 按 1—2—5 进位分九档。

误差不超过±10%(电源 110/220V)。

2. 微调比：≥2.5:1

输 入 阻 容：1MΩ//30pF

经 10:1 探极为 10MΩ//15pF

输 入 耐 压：400V(DC+ACp-p)

水平系统：

频 带 宽 度：10Hz～200kHz

输 入 阻 容：1MΩ//55pF

输入灵敏度：≤0.5Vp-p/div

扫 描 时 基： 1．0.1μS/div～10ms/div 按 1—2—5 进位分十六
档，误差不超过±10%（电源110/220V）

2．微调比。≥2.5:1

触 发 电 平：内触发：≥1div

外触发：≥0.5Vp-p

触 发 极 性：十，一

触　发　源：内、电视场、外

校准信号：

波　　　形：方波

频　　　率：等于使用电网的频率

幅　　　度：100mv 误差不超过±5%

示 波 管：

型　　　号：8SJ31J

加 速 电 压：1200V

屏幕有效工作面：6div×10div(1div＝0.6cm)

余　　　辉：中

其　　他：

工 作 环 境：温度－10°～＋40°C

相对湿度≤85%（30°C）

大气压力 750mmHg

使 用 电 源：110/220V±10%　50/60Hz

消 耗 功 率：约 55VA

工 作 时 间：可连续使用 8h

外 形 尺 寸：134B×200H×300Lmm

重　　　量：约 5.3kg

二、面板控制器

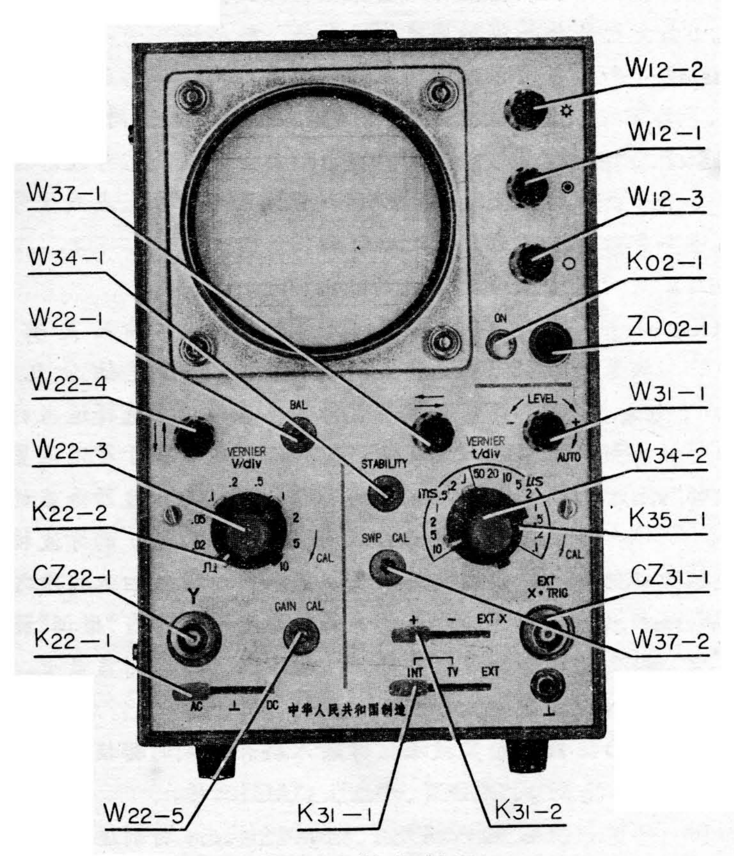


图 1 面板控制器

开(K_{02-1})　　仪器电源开关：当此开关扳向“开”时，指示灯(ZD_{02-1})即发红光，经预热时间后，仪器即可正常工作。

☼(W_{12-2})　　辉度调节装置：顺时针方向转动辉度加亮反之减弱，直至辉度消失。如光点长期停留在屏幕上不动时，宜将辉度减弱或熄灭，以延长示波管的使用寿命。

⊙(W_{12-1})	聚焦调节装置：用以调节示波管中电子束的焦距，使其焦点恰好会聚于屏幕上，此时显现的光点应成为清晰的圆点。
○(W_{12-3})	辅助聚焦：用以控制光点在有效工作面内的任何位置上散焦最小，通常与聚焦调节装置同时配合使用。
↑↓(W_{22-4})	垂直移位：用以调节屏幕上光点或信号波形在垂直方向上的位置，顺时针方向转动，光点或信号波形向上移，反之向下移。
Y(CZ_{22-1})	垂直放大系统的输入插座。
V/div(K_{22-2})	垂直输入灵敏度步进式选择开关：输入灵敏度自0.02/V/div～10V/div按1—2—5进位分九个档级，可根据被测信号的电压幅度，选择适当的档级位置，以利观测。当“微调”旋钮位于校准位置时，“V/div”档级的标称值即可视为示波器垂直的输入灵敏度。第一档级的“⊓⊔”为100mv的方波校准信号，供垂直输入灵敏度和水平时基扫速校准之用。
微调(W_{22-3})	用以连续改变垂直放大器的增益，当“微调”旋钮顺时针旋足，亦即位于校准位置时，增益最大。其微调范围大于2.5倍。
DC⊥AC(K_{22-1})	改变垂直被测信号输入耦合方式的转换开关。耦合方式分“DC”、“⊥”、“AC”三种。 “DC”输入端处于直流耦合状态，特别适用于观察各种缓慢变化的信号。 “AC”输入端处于交流耦合状态，它隔断被测信号中的直流分量，使屏幕上显示的信号波形位置，不受直流电平的影响。 “⊥”输入端处于接地状态，便于确定输入端为零电位时光迹在屏幕上的基准位置。
平衡(W_{22-1})	使垂直放大系统的输入级电路中的直流电平保持平衡状态的调节装置，当垂直放大系统输入端电路出

现不平衡时，屏幕上显示的光迹随“V/div”开关不同档级的转换和“微调”装置的转动而出现垂直方向的位移，平衡调节器可将这种位移减至最小。

增益校准（W_{22-5}） 用以校准垂直输入灵敏度的调节装置，可借助于“V/div”开关中“⊓⊔”档级的100mv方波信号，对垂直放大器的增益予以校准，使“微调”位于校准位置时，屏幕上显示方波波形的幅度恰为5div，

⇄（W_{37-1}） 水平移位：用以调节屏幕上光点或信号波形在水平方向上的位置，顺时针方向转动时，光点或信号向右移动，反之则向左移动。

t/div（K_{35-1}） 时基扫速步进式选择开关：扫描速度的选择范围由0.1μs/div～10ms/div按1—2—5进位分十六档级。可根据被测信号频率的高低，选择适当的档级。当扫速“微调”旋钮位于校准位置时，“t/div”档级的标称值即可视为时基扫描速度。

微调（W_{34-2}） 用以连续调节时基扫描速度，当该旋钮顺时针方向旋至满度，亦即处于“校准”状态，此时扫描位于快端。微调扫速的调节范围能大于2.5倍。

扫描校准（W_{37-2}） 水平放大器增益的校准装置，用以对时基扫描速度进行校准。在校准扫速时，可借助于“V/div”开关中“⊓⊔”档级100mv方波校准信号的周期，其周期的长短直接决定于仪器使用电源电网频率。例如电源电网频率f＝50Hz，则周期T＝20ms，此时可将“t/div”开关置于2ms/div档级，并调节“扫描校准”电位器，使屏幕上显示一个完整方波周期在水平方向的宽度恰为10div。若电源频率f＝60Hz则方波一个周期的宽度应校准为8.3div。

电平（W_{31-1}） 用以调节触发信号波形上触发点的相应电平值，使在这一电平上启动扫描。顺时针方向转动趋向信号波形的正向部分，反之趋向信号的负向部分。若将

“电平”顺时针旋至满度，并使此电位器连动的开关断开，使稳定度电位器的通地点断开，此时扫描电路处于自激状态。扫描电路在没有触发信号输入的情况下，也能自动进行扫描。

稳定度（W_{34-1}） 用以改变扫描电路的工作状态，一般应处于待触发状态，使用时只需调电平旋钮即能使波形稳定地显示。调整“稳定度”使扫描电路进入待触发状态其步骤如下：

（1）将垂直输入耦合方式开关（K_{22-1}）置于“⊥”，“V/div”置 0.02。

（2）用小起子把稳定度电位器顺时针方向旋足，此时屏上应出现扫描线，然后缓慢地向反时针方向转动，务使到达扫描线正好消失，此一位置即表示扫描电路业已到达待触发的临界状态。

＋ － 外接X（K_{31-2}） 触发信号极性开关：用以选择触发信号的上升或下降部分来触发扫描电路，促使扫描启动。当开关置于“外接 X”时，使“X·外触发”插座成为水平信号的输入端。

内 电视场 外（K_{31-1}） 触发信号源选择开关：当开关位于“内”时，触发信号取自垂直放大器中引离出来的被测信号。当开关位于“电视场”时，系将来自垂直放大器中被测电视信号，通过积分电路，使屏幕上显示的电视信号与场频同步。当开关位于“外”时，触发信号将来自“X·外触发”插座。输入的外加信号，它与垂直被测信号应具有相应的时间关系。

X·外触发（CZ_{31-1}） 为水平信号或外触发信号的输入端。

三、电路叙述

ST16型通用示波器的电路结构如后附方框图所示，其中包括垂直放大系统，扫描时基系统的触发放大器、整形器、扫描发生器和水平放大器，以及高低压电源供给装置，示波管显示控制和增辉电路，此外还附有以使用电源放大削波后构成的100mv方波信号校准器。各组成单元的工作原理分别叙述如下：

3.1 电源供给装置及校准信号

仪器的电源供给装置与校准信号单元中，除电源变压器B_{02-1}外，它的主要部件都安装于YB_1、YB_4二块印制板上。电源供给装置包括±15V稳压电源、+250V并由电阻分压而成的+200V和+60V三档直流电压，以及提供示波管显示控制电路用的−1200V高压电源。

−15V稳压电源：

由变压器B_{02-1}次级绕组12和13端输出的18V交流电压通过BG_{02-4}—BG_{02-7}组成的桥式整流转换为直流电压后，再经BG_{02-9}调整管和基极稳压管BG_{02-10}组成的串联稳压电路，用以提供稳定的−15V直流电源。为了降低这一稳压电源中的纹波含量，在提供调整管基极以及对作为基准电压的稳压管BG_{02-10}的供电电路中，接入用以抑制纹波的电子滤波网络，整流后直流电源中所含的纹波电压经R_{02-6}和C_{02-4}组成的低通滤波器，使BG_{02-8}基极上出现的纹波电压大大减小，而调整管BG_{02-9}射极的输出电压纹波同样地大大减小。

+15V稳压电源：

变压器次级绕组14和15端输出的18V交流电压，通过BG_{02-11}—BG_{02-14}组成的桥式整流转换成直流电压后，经BG_{02-15}调整管和基准稳压管BG_{02-16}所组成的串联稳压电路，提供稳定的+15V电源。由于提供BG_{02-16}的供电电源是直接取自−15V的稳压输出，因此BG_{02-16}所产生的基准电压实际上是经过两次稳压的，因而改善了+15V电源的稳定性和纹波含量。

+250V+200V和+60V电源：

变压器次级绕组7、8、9端所输出的260V交流电压通过BG_{02-1A}

$_{-B}$ $BG_{02-2A-B}$组成的全波整流电路，并经C_{02-1}、C_{02-2A}、R_{02-3}组成的π型滤波网络，转换为+250V直流电压，提供水平放大器和增辉放大的末级输出电路使用。同时经R_{02-4}降压产生+200V电压，供给垂直放大系统输出级中共栅放大电路和增辉放大电路，并通过降压电阻R_{02-5}馈至稳压二极管BG_{02-3}，产生稳定的+60V直流电源，供水平前级放大器使用。

—1200V高压电源：

变压器次级绕组8、10端输出1100V交流电压，通过G_{12-1}半波整流电路，并经分压器供示波管各控制电极使用。

校准信号：

校准信号系借助于变压器B_{02-1}次级绕组16、17端输出交流6.3V的电子管灯丝电压经电阻R_{02-13}降压后，馈接至BG_{02-18}基极。BG_{02-18}的发射极直接通地，而集电极的截止电压直接受基准稳压管BG_{02-17}限制(约6V)，因此当基极输入的交流电压超过一定幅度时，能促使BG_{02-18}集电极电位在饱和和截止两种状态交替转换，从而使基极输入的交流信号，通过其集电极的削波作用，而成为幅度恒定的方波信号，且不受电网电压变动的影响。通过对电位器W_{02-2}和电阻R_{02-12}的分压器的调整，使输出幅度恰为100mv，作为示波器自身对垂直灵敏度校准，借助于方波信号周期的宽度对水平时基扫速进行校准，以满足不同场合的定量测试。W_{02-1}对BG_{02-18}基极偏置工作点的调整，从而保证方波信号的高态与低态的宽度具有良好的对称性。

3.2 示波管显示控制系统和增辉放大电路

示波管电子枪中各电极的工作电压，系由—1200V高压电源通过R_{12-2}、W_{12-2}、R_{12-4}、W_{12-1}和R_{12-5}所组成的分压器分别供给。整流管G_{12-1}阳极为直流高压电源的负端，通过分压电阻R_{12-2}后，经电阻R_{12-6}馈入电子枪的控制极。又经辉度调节电位器W_{12-2}并经电阻R_{12-3}馈加于电子枪的阴极，而分压器中聚焦调节电位器W_{12-1}的中心臂，则与第一阳极直接相连，电子枪中位于控制极与第一阳极间的加速极，则另由+200V电源通过辅助聚焦调节电位器的中心臂连接。在调节W_{12-3}、W_{12-1}和W_{12-2}各电位器时，能使第二阳极、第一阳极和控制

极对阴极间的电位差分别+(1200～1400V)、+(200～400V)、和0～-100V范围之间。调节辉度电位器W_{12-2}，即改变了示波管控制极对阴极间的负电位，直接控制了示波管阴极发射电子束的能力，当控制极对阴极电位差超过-75V时，电子束处于截止状态，此时屏幕上所显示的光迹应告熄灭。调节聚焦电位器W_{12-1}，即改变第一阳极所形成的电子透镜对电子束的控制，保证电子束会聚于屏幕上。而调节辅助聚焦电位器是改变电子枪加速极和第二阳极电位，对电子透镜进行适当的修正，使光点散焦最最小。辉度、聚焦、辅助聚焦三者要配合调节，以保证屏幕所显示的光点或光迹有良好的聚焦质量。

增辉放大电路：

增辉放大电路由电子管G_{12-3}构成，来自扫描时基系统中闸门电路在正向扫描过程中所输出的负向闸门脉冲经射极跟随器BG_{34-4}和耦合电容C_{12-5}馈加于G_{12-3}放大器的栅极并经其倒相放大后成为正脉冲，经阴极跟随器和高压耦合电容C_{12-3}加至示波管的控制极，在扫描正程中控制极处于高电位，从而使辉度增亮。电路中二极管BG_{12-1}是用以保护阴极跟随器在开启电源时，栅阴间电位不致过高，以免遭致电子管损坏。电阻R_{12-7}和二极管BG_{12-2}的作用是使增辉脉冲后沿得以改善。

3.3 垂直放大系统

垂直放大系统电路结构包括二级共射极分差放大电路，并在这两级放大电路之间插入一射极跟随器，加强放大器级间的隔离作用，防止和减小放大电路前后相互牵连影响，放大系统的输入级采用场效应管的源极跟随器，使电路的输入阻抗得到相应提高，而放大系统的输出部分，则是由晶体管共射组态和电子管共栅放大的串接电路，用以提供示波管Y轴偏转板间需要较大的电压幅度的驱动信号，同时又减少由于电子管板栅电容所引起的密勒效应对共射电路的影响。

放大系统中1—2—5的倍率转换开关K_{22-2C}和增益校准装置都是改变各级分差电路两射极间的反馈量，亦即用以转换和调整放大系统的电压增益。为了使被测信号在示波管屏幕上显示波形能进行正确有效地观测，因此放大器输入端还装有RC频率补偿式的10:1、100:1

衰减网络，并与放大系统中第一级共射组态放大电路中的1—2—5倍率转换开关结合组成为V/div输入灵敏度选择开关K_{22-2}。放大系统中还装有移位装置，使屏幕上显示的波形能在垂直方向上下移动，此外垂直放大系统中还附有一射极跟随器将被放大了的被测信号，自第二级共射电路中引离出来，馈送至水平时基扫描系统中作为内触发信号之用。

被测信号经Y输入插座CZ_{22-1}输入，经耦合选择开关K_{22-1}及“V/div”灵敏度选择开关K_{22-2}进入放大电路的输入源跟随器BG_{22-2}。当耦合开关K_{22-1}于“AC”位置时，被测信号将经过耦合电容C_{22-1}，阻隔输入信号中的直流分量，但被测信号将受到耦合电容的容抗影响，在观察低频信号时会产生频率畸变出现脉冲平顶下垂等现象。为消除这一缺陷，一般可将耦合选择开关置于“DC”位置，成为直流耦合状态，如果输入信号含有直流分量，则屏幕上显示的信号波形将会偏离基线，其偏离程度与直流分量的大小有关。为了使被测信号能在有效工作面内进行正确的观察，借助于V/div开关，将馈送给BG_{22-2}栅极前的过大的被测信号进行10:1或100:1的衰减，并对放大器增益进行1—2—5的倍率转换。10:1和100:1衰减器，系由具有频率补偿的RC衰减网络所组成，它在低频时主要为电阻分压；在高频时，衰减网络的分压比主要由电容分压器所决定，如果将电容分压器加以调节，使其容抗比等于电阻分压比，则此衰减网络的频率特性将得到良好的补偿。电原理图中的C_{22-3}、C_{22-7}即为用以调整网络电容分压比的可调电容器。而C_{22-2}和C_{22-6}为衰减网络的并联电容，用以校准衰减网络的输入电容，使灵敏度开关的各个档级均能达到预定的输入电容量，这样在使用RC衰减式探极时，不论灵敏度开关位于任一档级位置都能满足探极的阻容常数。

放大电路的输入级是采用场效应管的源极跟随器，提高了电路的输入阻抗，源极跟随器的栅极输入端串接有电容C_{22-9}和电阻R_{22-6}组成的RC并联限流网络，并以BG_{22-1}的集电结作为箝位二极管，是用以防止输入信号过大，而导致源极跟随器的损坏。BG_{22-3}为一直流平衡管，与BG_{22-2}组成对称的平衡电路，用以减少温度和电源等变化所

引起的漂移。BG_{22-3}栅极上的直流电位，可借助于平衡调节电位器W_{22-1}上中心动臂输出的直流电位来加以调节，并通过其源极输出端馈接于BG_{22-5}的基极，使整个放大器在最佳直流平衡状态。由BG_{22-4}、BG_{22-5}组成的第一级共射极分差放大电路，其电压增益受两射极间的反馈电阻所控制，并借助于“V/div”转换开关对串接的反馈电阻R_{22-18}、R_{22-19}和R_{22-20}按1—2—5的倍率比值进行转换，同时与10:1、100:1的输入衰减网络组合下，使输入灵敏度自0.02V/div～10V/div分成九个档级。BG_{22-4}和BG_{22-5}的射极电源系通过电位器W_{22-2}分别经R_{22-16}、R_{22-17}与两射极连接，调整W_{22-2}亦即改变BG_{22-4}和BG_{22-5}的射极电阻，以保证两集电极间的直流电位趋于相等。经两集电极输出的放大信号，通过BG_{22-6}、BG_{22-7}的射极跟随器经电阻R_{22-27}和R_{22-28}分别馈于由BG_{22-8}、BG_{22-9}组成的第二极共射放大器的两个基极，并与连接于两基极间的电阻R_{22-30}和电位器W_{22-3}构成电阻分压网络，调节W_{22-3}即改变了分压网络的分压比，从而达到对输入灵敏度微调的目的。由于射极跟随器的输出阻抗较低，因而对调节微调电位器W_{22-3}所引起的电容变化对放大电路的频响影响，完全可以忽略不计。BG_{22-8}、BG_{22-9}两射极间的反馈电阻R_{22-33}和由R_{22-34}、C_{22-13}、C_{22-19}所构成的阻容串联网络，是用于调整电路的电压增益和改善电路的高频相移特性。被放大了的信号，由两集电极输出，并馈送给由BG_{22-11} BG_{22-12}和G_{22-1a}、G_{22-1b}组成的晶体管、电子管混合结构的共射共栅串接分差放大电路，由于共栅放大电路的两栅极接有电容C_{22-16}接地，因此能使这一放大电路的阴栅输入端和板栅输出端具有良好的隔离，因而消除了由板栅电容所引起的密勒效应对输入电路的影响，从而改善了电路的高频特性。此外共射放大电路具有较大的电流增益，而被放大了的集电极电流与串接的共栅电路的板流一致，且通过负载电阻R_{22-50}、R_{22-51}，因此G_{22-1a}和G_{22-1b}两板极输出端能提供示波管Y轴偏转板需要的较大幅度的驱动电压。共射电路的两射间串接的电位器W_{22-5}以及电阻R_{22-46}、R_{22-47}、C_{22-15}的补偿网络，作对整个放大电路的电压增益进行校准及改善电路的瞬态特性之用。在BG_{22-11}、BG_{22-12}的基极输入电路中还装有双连电位器W_{22-4a}、W_{22-4b}，用以调节两基

极的注入电流，使 G_{22-1a}、G_{22-1b} 两板极间输出的直流电位产生相应的改变，从而达到屏幕上的信号波形在垂直方向上下移位的目的。

在第二级共射分差放大电路 BG_{22-8} 的集电极，将输出的部分垂直信号，经射极跟随器 BG_{22-10} 分离引出，馈送至时基扫描系统的触发源选择开关，作为仪器的内触发信号之用。

3.4 水平时基扫描系统

ST16 型示波器水平时基扫描系统的电路结构，包括有触发放大、整形电路、扫描信号的形成和控制电路、水平放大器等组成单元，在通过水平放大器放大并校准后的扫描电压作为时基信号馈加于示波管的 X 轴偏转板，使加于垂直偏转板间的被测信号按时基变化的波形图象，在屏幕上显示出来，便以进行观察。

扫描信号是由扫描闸门电路对受开关管控制的时间电容经恒流电源充电，并通过开关管放电而形成。来自时间电容并经放大后的扫描信号，通过释抑电路的作用，对用以启动闸门电路的触发脉冲进行控制，从而使扫描电压的输出幅度以及扫描的起始电平都能保持恒定一致。时基扫速的变换是借助于“t/div”开关对时间电容进行置换，以及改变恒流电源的限流电阻而达到的，并利用对恒流源的电压调节，使档级间的扫描达到连续微调的目的。由扫描闸门输出的负向闸门脉冲经射极跟随器并经放大，作为示波管的增辉信号。现将各单元工作原理分别叙述如下：

触发放大和整形电路：来自垂直放大系统中由射极跟随器 BG_{22-10} 引离出来的内部触发信号，或由“X 外触发”输入插座 CZ_{31-1} 输入的外加触发信号，分别通过触发源选择开关 K_{31-1b} 馈接于源跟随器 BG_{31-3} 的栅极，以场效应源跟随器作为触发放大电路的输入器，除了用以提高电路的输入阻抗外，并能使触发电路与触发源隔离，以减少电路间的相互影响。BG_{31-3} 栅极的输入端串接有电容 C_{31-2} 电阻 R_{31-2} 组成的 RC 并联限流网络和箝位二极管 BG_{31-1}、BG_{31-2}，用以防止输入信号过大而导致源跟随器的损坏。为了使触发信号的上升和下降区域能同样地对扫描闸门电路进行触发，可将 BG_{31-3} 源极上输出的触发信号通过耦合电容后，借助于触发极性选择开关 K_{31-2a} 按触发点选择于信

号的正向上升区域或负向下降区域，亦即按触发点的“+”“—”极性分别馈给由 BG_{31-4} 和 BG_{31-5} 组成的分差放大器的基极，此时分差放大器另一个基极输入端则通过开关 K_{31-2d} 与由 R_{31-19}、R_{31-20} 和触发电平电位器 W_{31-1} 组成的分压网络相连。若采用触发信号的正向上升区域，此时触发信号加于 BG_{31-4} 的基极，而 BG_{31-5} 的基极应连接于“电平”的直流分压网络，调节“电平”使 BG_{31-5} 基极上有一相应的直流参考电平，此一电平的大小应与 BG_{31-4} 基极上的信号触发点的电位基本相应，当触发信号正向上升区域上升到达与 BG_{31-5} 基极直流参考电平相近时，BG_{31-4} 的集电极电流便迅速增加，而其电压相应下降，此时 BG_{31-4} 集电极的变化电压通过由 BG_{31-6}、BG_{31-7} 组成的许密特电路，使 BG_{31-7} 集电极输出负向矩形脉冲，然后通过 C_{31-6} 和 C_{31-17} 组成的微分网络以及由二极管 BG_{31-8}、BG_{31-9} 组成的削波电路后，由耦合电容 C_{31-7} 输出负向触发脉冲，用以对扫描闸门电路进行触发。当触发源选择开关 K_{31-1} 位于“电视场”时，源跟随器 BG_{31-3} 输出的触发信号（亦即来自垂直放大系统的电视信号）通过电阻 R_{31-4} 和电容 C_{31-8} 组成的积分网络积分，将场同步信号分离出来，经耦合电容 C_{31-4} 送入分差放大器，经整形、微分和削波等电路后对扫描闸门进行触发。

扫描信号形成和控制电路：

用以控制开关管 BG_{34-6} 工作的扫描闸门电路系由 BG_{34-2}、BG_{34-3} 组成的许密特电路，当脉冲尚未来临前，若“稳定度”电位器位于待触发状态，此时 BG_{34-2} 应处于导通，而 BG_{34-3} 应为截止状态，因此 BG_{34-3} 集电极处于高电位，其通过 R_{34-10}、R_{34-11}、R_{34-12} 组成的分压网络和二极管 BG_{34-5} 使开关管 BG_{34-6} 进入临界饱和状态，此时时间电容 C_{35-7}～C_{35-13} 为低电位。当来自触发电路耦合电容 C_{31-7} 的负向触发脉冲到达 BG_{34-2} 的基极，且其幅度足够促使闸门电路翻转，BG_{34-3} 集电极由高电位转为低电位迫使开关管 BG_{34-6} 截止，此时时间电容将通过恒流管 BG_{34-7} 充电，使其电位线性上升，形成正向的扫描信号（扫描正程），其上升速度由时间电容 C_{35-7}～C_{35-13} 的电容量和恒流管所串接的限流电阻 R_{35-1}～R_{35-4} 所决定，同时还可借助电位器对恒流管基极的直流电位进行调整，改变恒流管发射极限流电阻两端的电压，

从而达到扫速微调的目的。时基电容上的电位变化通过 BG_{34-8}、BG_{34-9} 所组成的两级射极跟随器，除经 R_{34-24}、R_{34-25} 分压网络，并借助于触发极性开关 K_{31-2b} 馈送给水平放大器经放大并校准后作为扫描时基信号供示波管 X 轴偏转板外，同时由 BG_{34-9} 射极的电阻分压器经隔离二极管 BG_{34-10} 对释抑电容 C_{35-1}～C_{35-6} 进行充电，使其电位随正向扫描信号上升，直至 BG_{34-2} 基极上的偏置电位能促使闸门电路翻转，即 BG_{34-2} 导通，BG_{34-3} 截止，而 BG_{34-3} 集电极由低电位跃升至高电位时，迫使开关管 BG_{34-6} 重新导通，时间电容立即通过开关管集电极放电降为低电位（扫描逆程），并通过两级射极跟随器使隔离二极管 BG_{34-10} 转入截止状态。此时释抑电容上的电位将通过 BG_{34-2} 进行放电，直至隔离二极管 BG_{34-1} 由截止转入导通，并使释抑电容器的电位暂时保持不变，等待来自 C_{31-7} 的负向触发脉冲，开始下一个扫描过程。其扫描输出的电压幅度，可由 BG_{34-9} 射极电阻分压器中的 W_{34-3} 加以调整决定。扫描信号的逆程时间由释抑电容的大小和开关管集电极发射极间在导通过的内阻决定。为了保证时间电容放电尚未到达充分稳定前，不使闸门电路因受到来自触发电路触发脉冲的作用而提前翻转，而造成扫描起始电平的参差不一，使屏幕显示的波形发生水平方向的抖动，故采用了放电时间常数大于扫描逆程时间的释抑电路，以使 BG_{34-2} 基极偏置电位受释抑电容电位的作用，对触发脉冲不产生触发作用。

若将"稳定度"电位器 W_{34-1} 中心臂调离待触发状态而置于最负位置，或将"电平"电位置 W_{31-1} 顺时针旋足，并使其连动开关将 W_{34-1} 接地端切断，此时释抑电容电位在放电过程中将不会使隔离二极管 BG_{34-1} 导通而继续下降，直至 BG_{34-2} 的基极电位在没有触发脉冲输入的情况下，能使闸门自动翻转，此时扫描电路转为自激状态。

扫描闸门电路输出的负脉冲，除用以控制开关管外，并通过射极跟随器 BG_{34-4} 将该脉冲经电容 C_{12-15} 馈送给增辉信号放大器放大作增辉信号。

水平放大器：

水平放大器由两级电子管直接耦合的分差放大电路组成，来自扫

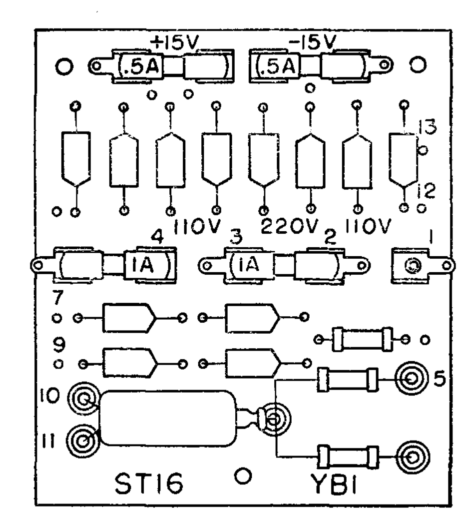
描信号形成和控制电路所输出的扫描信号，或由“X·外触发”插座所输入的外接X信号，可借助于触发极性开关K_{31-2b}和K_{31-2c}馈加于G_{37-1a}的栅极。G_{37-1b}为一直流平衡管，其栅极电位可由水平移位电位器W_{37-1}并通过电阻R_{37-5}与R_{37-6}组成的分压器得到调节，使两级分差放大器的板极间的直流电位产生相对变化，从而达到平衡和移位的目的，放大电路的电压增益，分别由分差放大电路阴极间所串接的W_{37-2}和R_{37-9}所控制，借助W_{37-2}的调整，从而对输出的扫描时基信号速率达到校准的目的。电容C_{37-2}和电容C_{37-3}皆为高频补偿电容，用以改善水平放大器的频响特性。放大电路中二极管BG_{37-1}和BG_{37-2}是用以保护电子管在开机时不使栅阴电位差过大而遭致损坏。

四、使用方法

4.1 使用前注意事项

仪器使用前对本说明书中的技术性能、控制机件的作用以及使用方法等有关章节事先如能参阅一遍，这对如何正确和有效地掌握仪器的使用范围及其操作方法等方面，都会带来一定的帮助。

仪器电源与电网电压连接前应注意供电电网电压与仪器电源的适应电压应相符。仪器出厂时规定的适应电压为220V，如使用场合的供电电网电压为110V时，应将仪器后盖板打开，并将位于机内下方的印制板YB1上的保险熔丝BX_{02-2}和BX_{02-1}取下按图4.1所示位置按置，使仪器电源的适应电压为110V。



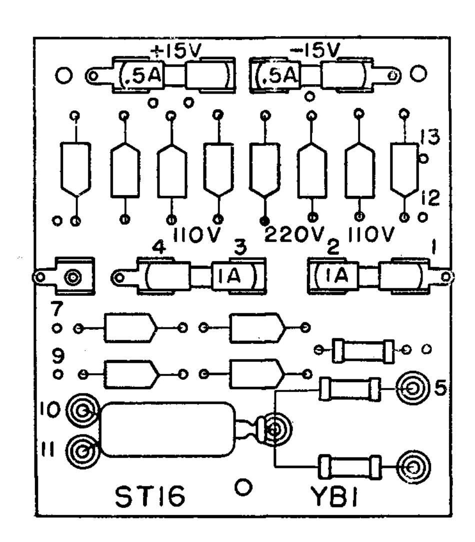
电源为 220V 时

图 4.1

4.2 使用前的检查

本仪器初次使用前，或久藏复用时，有必要对仪器进行一次能否工作的简单检查，其方法步骤如下：

（1）将仪器面板上各个控制机件置于表4.1位置：



电源为110V时

图 4.1

表 4.1

控制机件	作用位置	控制机件	作用位置
☼	逆时针旋足	电平	自动
⊙	居中	t/div	2 ms
○	居中	微调	校准
↓↑	居中	＋ 一外接 ×	＋
⇆	居中	内 电视场 外	内
V/div	⊓⊔		
微调	校准		
AC ⊥ DC	⊥		

（2）接通电源，指示灯应有红光显示，稍待片刻，仪器应能进入正常工作。

（3）顺时针调节“☼”辉度电位器，此时屏幕应显示出不同步的校准信号方波。

（4）将触发电平调离“自动”位置，并向反时针方向转动直至方波波形得到同步，然后将方波波形移至屏幕中间，如若仪器性能基本正常，则此时屏幕显示的方波垂直幅度值约为 5div，方波周期在水平轴上的宽度约为 10div（电网频率 50Hz）或 8.3div（电网频率 60Hz）。见图 4.2。

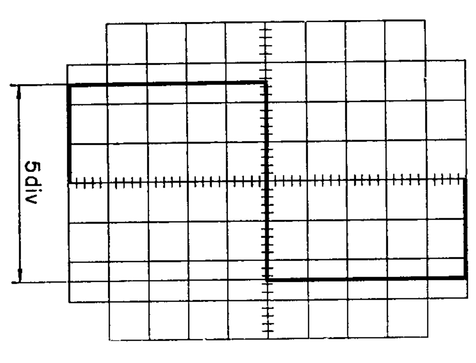


图 4.2

4.3 使用前的校准

（1）当仪器已符合上述(4.2)节要求，并等待数分钟后，应调节面板上的“平衡”电位器(W_{22-1})务使改变灵敏度V/div档级开关时，显示的方波波形不发生Y轴方向上的位移。

（2）示波管的加速电压值(—1200V)的大小系受电网电压值变化的牵制，当电网电压偏离仪器电源的适应电压 220V 或 110V 时，将直接影响示波管的偏转灵敏度，从而使垂直输入灵敏度 V/div 和水平时基扫速 t/div 造成较大的误差，因此仪器在使用前必须对垂直系统的增益校准(W_{22-5})和水平系统的扫描校准(W_{37-2})分别进行校准，务使屏幕上所显示的校准信号的垂直幅度恰为 5div，周期宽度恰为 10div 或 8.3div。

4.4 电压测量

当仪器如已完成上述4.3节的简单校准后，即可对被测信号波形的电压幅度进行定量测定。

直流电压测量：

被测信号中，如含有直流电平，且此直流电平亦需进行测量时，首先应确定一个相对的参考基准电位，一般情况下的基准电位直接采用仪器的地电位，其测量步骤如下：

（1）垂直系统的输入耦合选择开关置于“⊥”，触发“电平”电位器位于“自动”，使屏幕出现一条扫描基线，并按被测信号的幅度和频率将V/div档级开关和t/div扫速开关置于适当位置，然后调节“↓↑”垂直移位电位器，使扫描基线位于坐标片如图4.3所示的某一特定基准位置(0V)。

（2）将输入耦合选择开关改置于“DC”位置。并将被信号直接或经10:1衰减探极接入仪器的Y轴输入插座CZ_{22-1}，然后调节触发“电平”使信号波形稳定。

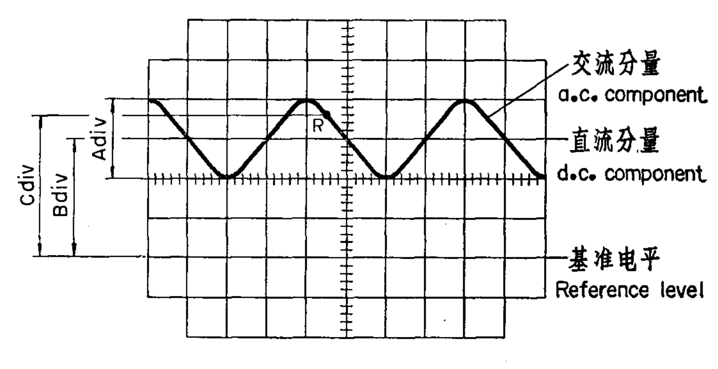


图 4.3

（3）根据屏幕坐标刻度，分别读出显示信号波形的交流分量（峰——峰）为Adiv，直流分量为Bdiv以及被测信号某特定R点与参考基线间的瞬时电压值为Cdiv。若仪器V/div档级的标称值为0.2V/div，同时Y轴输入端使用了10:1衰减探极，则被测信号的各电压值分别为：

被测信号交流分量：$V_{P-P}=0.2V/div\times Adiv\times 10=2A(V_{P-P})$

被测信号直流分量：$V=0.2V/div\times Bdiv\times 10=2BV$

被测信号R点瞬时值：$V_R=0.2V/div\times Cdiv\times 10=2CV$

交流电压的测量：

一般是直接测量交流分量的峰——峰值，测量时通常被测信号通过输入端的隔直电容，使信号中所含有的交流予以分离，否则被测信号的交流与直流分量迭加后往往会超过放大器的有效动态范围，不得不采用较低的输入灵敏度档级，从而影响交流分量的测量精度，因此除了被测信号中交流分量的频率较低，耦合电容对信号具有较大的容抗，对被测信号引起一定的误差，所以仍应按上述直流电压的测量方法外，而交流电压的一般测量应按如下步骤：

(1)垂直系统的输入耦合选择开关置于"AC"，V/div 档级开关和 t/div 扫速开关根据被测信号的幅度和频率选择适当的档板，并将被测信号直接或通过 10:1 探极输入仪器的 Y 轴输入端，调节触发"电平"使波形稳定，如图 4.4。

(2)根据屏幕的坐标刻度，读测显示信号波形的峰——峰值为 Ddiv，如仪器 V/div 档级标称值为 0.1V/div，且 Y 轴输入端使用了 10:1 探极，则被测信号的峰——峰值应为：

$$V_{P-P}=0.1V/div\times Ddiv\times 10=DV$$

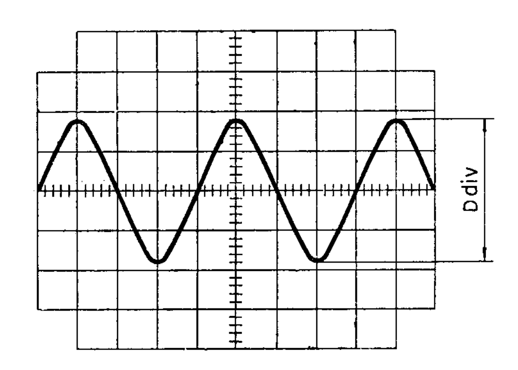


图 4.4

4.5 时间测量

当仪器如已按 4.3 节对时基扫速 t/div 校准后，即可对被测信号波形上任意两点的时间参数进行定量测量。其步骤如下：

(1)按被测信号的重复频率或信号波形上两特定点 P 与 Q 的时间间隔，选择适当的 t/div 扫速档级，务使两特定点的距离应在屏幕的有效工作面内到达最大限度，以便提高测量精度，见图 4.5。

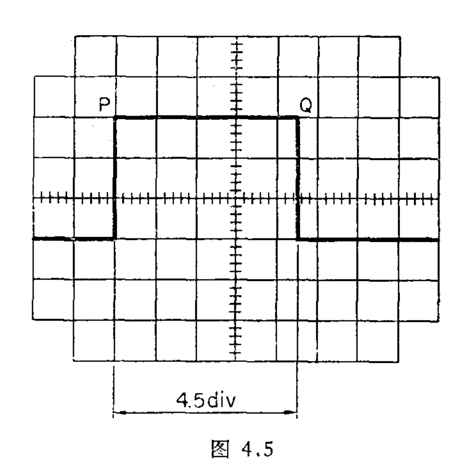


图 4.5

(2)根据屏幕坐标片的刻度，读测被测信号两特定点 P 与 Q 间的距离为 Ddiv，如 t/div 扫描开关档级的标称值为 2ms/div，D=4.5div 则 PQ 两点的时间间隔值 t：

$$t=2ms/div\times Ddiv=2Dms=9ms$$

4.6 脉冲上升时间的测量

仪器如已按 4.3 节对时基扫速 t/div 校准后，即可对脉冲的前沿上升时间进行测定，其测量步骤如下：

(1)按照被测信号的幅度选择 V/div 档级，并调节灵敏度"微调"电位器，务使屏幕上所显示的波形垂直幅度恰为 5div。

(2)调节触发"电平"及"⇄"水平移位电位器，并按照脉冲前沿上升时间的宽度，选择适当的 t/div 扫速档级，使屏幕上显示信号波形如 4.6 所示。

(3)根据屏幕坐标刻度上显示的波形位置，读测信号波形的前沿在垂直幅度的 10% 与 90% 两位置间的时间间隔距离为 Ddiv，若 t/div 扫速档级的标称值为 0.1μs/div，D=1.6div，则前沿上升时间为 t_{γ}，

$$t_{y}=\sqrt{t_1^2-t_2^2}=\sqrt{(1.6\times100)^2-70^2}\simeq144(ns)$$

其中：t_1 为垂直幅度 10% 与 90% 的时间间隔

t_2 为仪器固有上升时间，约为 70ns

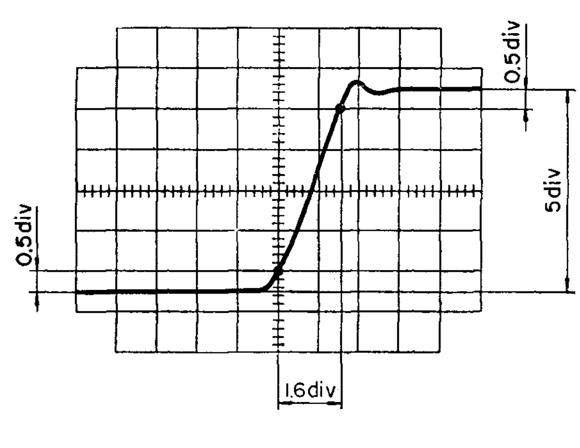


图 4.6

4.7 频率测量

对于重复信号的频率测量，一般可按 4.5 节的时间测量的步骤测出信号的周期，并按其倒数算出其频率值，其正确度将决定于周期的测量精度。

例如某重复信号测得其周期 T=4μs，则频率

$$f=1/T=1/(4\times10^{-6})=0.25\times10^{6}=250(kHz)$$

如若借助于已知频率的信号发生器，并利用李沙育图形方法亦可测出信号的频率值，但其精度将直接决定于已知频率信号发生器的频率误差，其测量步骤如下：

(1)将被测信号 $f_{(y)}$ 输入仪器的 Y 输入插座，而将已知频率信号 $f_{(x)}$ 输入于仪器的“外接 X”输入插座。

（2）根据屏幕上显示的李沙育图形的比值以及已知频率信号 $f_{(x)}$ 计算被测信号的频率值 $f_{(y)}$。

图 4.7 为 Y 轴和 X 轴均输入正弦波的李沙育图形，图中的比值是 $f_{(y)}:f_{(x)}$

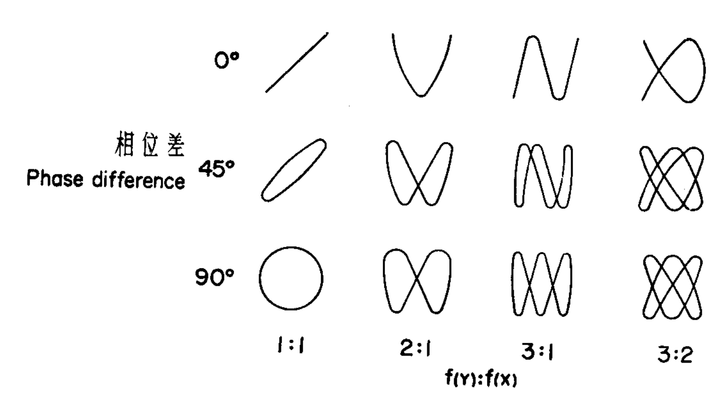


图 4.7

4.8 相位测量

在许多场合下，可利用示波器测量某一网络的相移，例如要测量正弦波通过放大器后的滞后相角值，其方法和步骤如下：

方法 A：

（1）将仪器的触发源选择开关 K_{31-1} 置于“外”，同时将导前的信号 A 分别接入仪器的 Y 轴输入插座 CZ_{22-1} 和外触发输入端 CZ_{31-1}，然后调节“t/div”扫速开关、扫速“微调”和触发“电平”使屏幕上所显示信号的周期宽度在 X 轴上的坐标刻度恰为 9div，这样 X 轴上的座标刻度值就直接与信号的相角值相对应即 360°/9div＝40°/div。

（2）读测导前信号波形 A 的特定点P， 在 X 轴上的位置。同时对仪器的外触发信号、“t/div”开关、扫速“微调”、触发“电平”和“⇆”水平移位电位器皆应保持不变，然后将原输入 Y 轴的导前信号A，改为滞后的信号B，并读测滞后信号在 X 轴上的相应特定点 P′ 的位置，见图 4.8A。

（3）根据两特定点 P、P′ 的距离 Ddiv，并计算两信号间的相移。

$$\phi = \text{Ddiv} \times 40°/\text{div} = 40\text{D}°$$

若 D＝2.25div 则 $\phi = 90°$

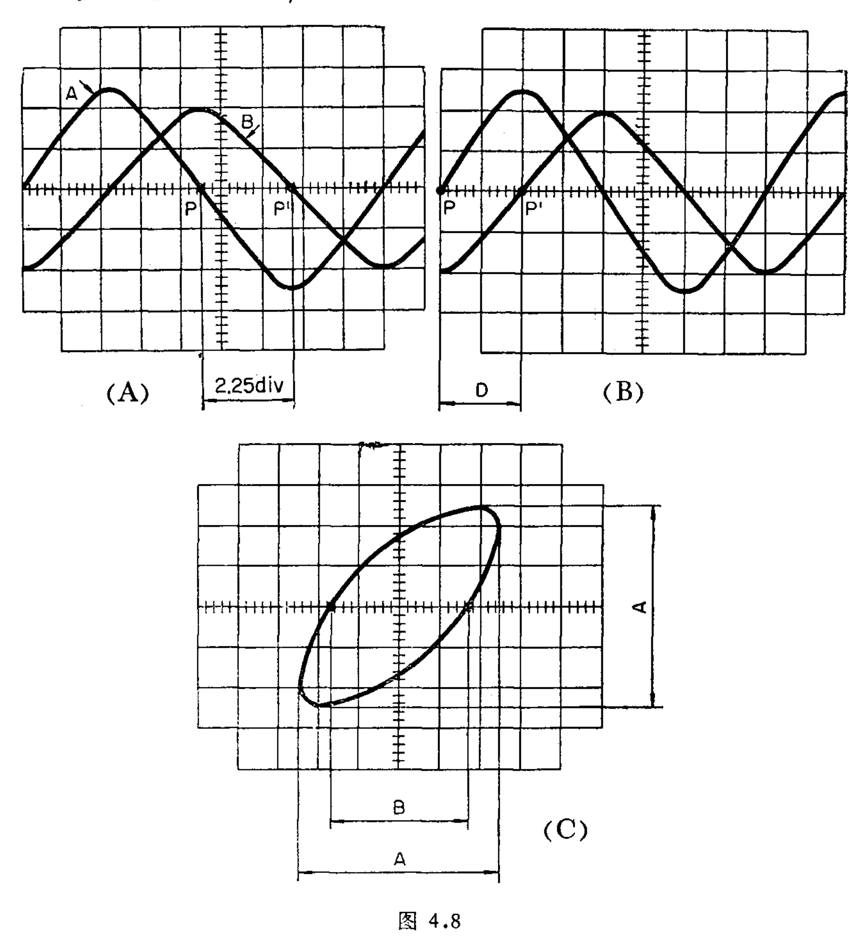


图 4.8

方法 B：

具体测量步骤基本上与方法 A 相似，但屏幕上所显示信号周期宽度在 X 轴上的刻度为 T div（不必恰为 9div），读测两信号的两相应特定点 P、P′ 的距离为 Ddiv（见图 4.8B），则两信号的相移 ϕ：

$$\phi = \frac{D}{T} \times 360°$$

方法C：李沙育图形法：

（1）将仪器的触发极性开关K_{31-2}置"外接X"位置，导前信号A接入仪器的外接X插座，并控制此输入信号幅度，使屏幕X轴向显示的幅度为Adiv。然后再将滞后信号B接入Y输入插座，调节仪器"V/div"开关和灵敏度"微调"电位器，使屏幕Y轴向上所显示波形幅度亦恰为Adiv。见图4.8C所示。

（2）读出图形曲线与X轴相交的两截点的距离Bdiv，则两信号间的相角差为ϕ：

$$\phi = \arcsin\frac{B}{A}$$

4.9 磁滞回线显示

本仪器亦可作为XY图示仪，例如可借助于磁场强度H与其函数磁通密度B所显示的B/H曲线，对磁性材料的性能进行直接比较，其方法如图4.9所示，其中由于通过初级绕组N_1的电流正比于磁场强度H，因此电阻R_1两端所产生的电压可直接与磁场强度H相应，将此电压加于仪器的X轴。次级绕组N_2所感应的电压Vs正比于磁通密度B，R与C组成的积分网络如$R \geqslant \frac{1}{\omega C}$，则电容C两端的电压Vc将与磁通密度B相应，将此电压加于Y轴，仪器屏幕上所显示的B/H曲线亦即磁滞回线。

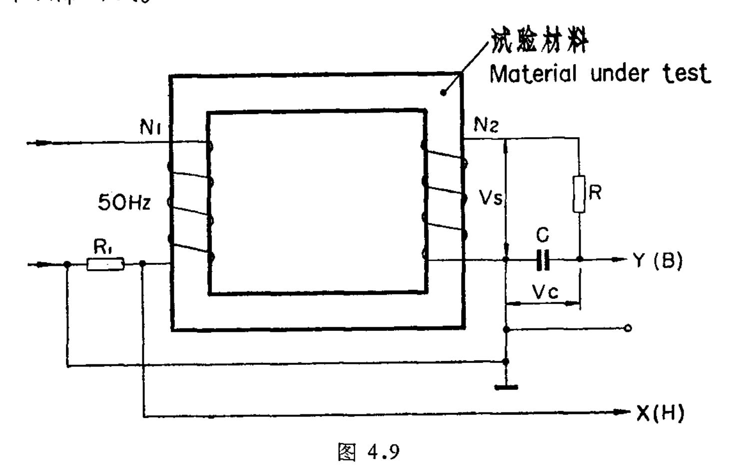


图 4.9

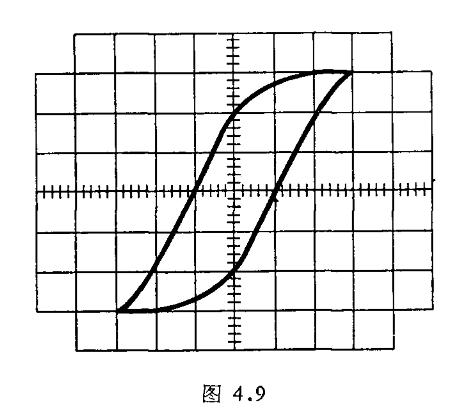


图 4.9

五、仪器的调整

仪器经过较长时间的使用或经过大修，一般应该进行一次全面的调整，进行调整需要具备的仪器及其主要性能如表 5.1 所示。

表 5.1

序号	仪器名称	主要性能
1	宽频带信号发生器	频宽 10Hz～20MHz 输出幅度 >500mv，带输出畸变指示器
2	方波信号发生器	幅度 0～100V ±1.0% 频率 1KHz
3	时标信号发生器	0.1μs～10ms ±1%
4	万用电表	量程 0～50V，0～500V，0～2500V ±2.5% 内阻 20KΩ/V
5	交流电压表	0～300V 1%

为保证仪器的调整精度，在调整过程中，仪器供电应以交流电压表监视，经调压变压器调整为 220V。

5.1 直流电源的调整

本机直流电源包括 ±15V 稳压，未稳压的 +250V 及经阻容分压的 +200V、稳压的 +60V，以及示波管高压 −1200V，用电压表测量各电压点应符合表 5.2 规定范围。

表 5.2

电压点	测量部位	电压范围	备　　注
+ 250V	$YB3_{(1)}$	≃260V	
+ 200V	$YB2_{(1)}$	≃200V	
+ 60V	$YB3_{(2)}$	55～60V	稳压
+ 15V	$YB4_{(1)}$	15～16.5V	”
− 15V	$YB4_{(7)}$	−15～16.5V	”
− 1200V	$G_{12-2(2)}$	≃−1200V	

5.2 Y 轴放大器平衡调整

本仪器 Y 轴放大器所用之晶体管，均经工厂挑选配对。若管子已损坏必须更换，应将与其成对的管子焊下，进行配对挑选（主要是 h_{fe} 配对），以免使平衡难以调整。

Y 轴放大器平衡调整方法如下：

（1）将有关控制机件置于下列位置：

“＋ － × 外接”：× 外接

Y 轴“微调”：校准

“⇆”：居中

“↑↓”：居中

将整机预热数分钟，此时光点在水平方向上约在屏幕的中间。

（2）调节面板上的Y轴平衡电位器（W_{22-1}），使"V/div"开关调节时光点不发生移位，此时再调节机内的平衡电位器（W_{22-2}），使光点垂直方向上也在屏幕中间，如此数次反复，直至"V/div"开关不论转到任何位置，光点都不发生移位，且Y轴移位居中时，光点也在屏幕中间。

5.3 Y轴衰减器及探极补偿的调整

（1）将调试整机各控制机件置于下列位置：

"t/div"开关：0.2ms

扫速"微调"：校准

"＋ － × 外接"：＋

"内 电视场 外"：内

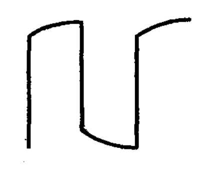
"AC⊥DC"：AC

Y轴"微调"：校准

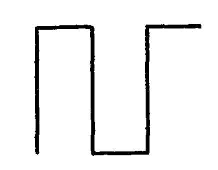
（2）将方波信号发生器输出的1KHz方波加于Y轴输入端，调整触发"电平"使波形触发，顺次改变方波信号发生器的输出幅度及V/div开关档级，并调整相应元件，使屏上显示方波如图5.1中临界补偿的波形。其调整关系如表5.3。

表 5.3

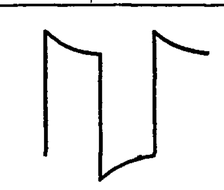
V/div 开关档级	方波信号发生器输出幅度	屏幕显示幅度	调 整 元 件
0.02	0.1V	≃5div	—
0.2	1V	≃5div	C 22—3
2	10V	≃5div	C 22—7



欠补偿
Under compensation



临界补偿
Critical compensation



过补偿
Over-compensation

图 5.1

（3）将探极接于Y轴输入端，将发生器1KHz方波经探极输入调试整机的Y轴，调整探极电容和机内元件，使波形达到图5.1临界补偿的要求。其调整关系如表5.4。

表 5.4

V/div 开关档级	输出幅度	屏幕显示幅度	调整元件
0.02	1 V	≃5div	探极结构电容
0.2	10 V	≃5div	C_{22-2}
2	100 V	≃5div	C_{22-6}

5.4 Y轴输入敏灵度及校准信号调整

（1）将调试整机供电电源保持在220V±2%范围内，将各控制机件置于下列位置：

"t/div"开关：0.2ms　　"AC⊥DC"：AC

扫速"微调"：校准　　Y轴"微调"：校准

"＋ － × 外接"：＋　　"V/div"开关：0.02

"内 电视场 外"：内

（2）将100mv方波信号输至Y轴输入端，调整Y轴"增益校准"，使屏上显示方波恰为5div，然后将V/div开关置于"ЦП"，并将t/div开关置于5ms，其他控制机件位置不变，调整 W_{02-2}，使屏幕上显示波形恰为5div。

（3）将t/div开关回到0.2ms，顺次改变方波信号发生器的输出幅度和V/div开关位置，屏上显示的方波幅度应符合表5.5要求。

表 5.5

方波信号发生器输出幅度	V/div开关位置	显示幅度	误差范围
100mv	0.02	5div	校　准
250mv	0.05	”	±10%
500mv	0.1	”	”
1V	0.2	”	”
2.5V	0.5	”	”
5V	1	”	”
10V	2	”	”
25V	5	”	”
50V	10	”	”

5.5 扫描速度调整

（1）调整整机供电电源仍保持在220V±2%范围内。将各控制机件置于下列位置：

t/div 开关：1ms

扫速“微调”：校准

触发“电平”：逆时针旋足

“＋ － × 外接”：＋

“内 电视场 外”：内

“AC⊥DC”：AC

（2）将时标信号发生器置于1ms，其输出接调试整机之Y轴输入，调整“V/div”开关及Y轴“微调”，使屏幕上显示的脉冲幅度为2～3div，顺时针旋转触发“电平”，使扫描触发。

（3）调整面板的"扫描校准"，使屏幕上在10div的扫描线长度上正好显示11个波峰(即10个周期)。然后调节扫描长度电位器W_{34-3}，使扫描长度为11.div～11.5div。

（4）按表5.6顺次改变t/div开关位置及时标信号发生器输出波形的周期，在10div扫描长度上显示的波峰数及其误差应符合表5.6要求。

表 5.6

时标信号发生器档级	t/div 开关档级	显示特征 波峰/10div	误差范围
10 ms	10 ms	11	±10%
	5 ms	6	”
	2 ms	3	”
1 ms	1 ms	11	校 准
	0.5 ms	6	±10%
	0.2 ms	3	”
100 μs	0.1 ms	11	”
	50 μs	6	”
	20 μs	3	”
10 μs	10 μs	11	”
	5 μs	6	”
	2 μs	3	”
1 μs	1 μs	11	”

（5）在校准最后三档扫速（即0.5μs、0.2μs、0.1μs）时应先将

“t/div”开关置于0.1μs，时标信号发生器亦置于0.1μs，调整C_{35-7}使屏上10div长度内显示11个波峰，再将t/div开关置于0.2μs此时屏上在10div长度内应显示19～23个波峰（即误差±10%）。

（6）将t/div开关置于0.5μs、时标信号发生器置于1μs，此时在10div长度上应显示6个波峰，误差为±10%。

5.6 频率响应调整

（1）将调试整机面板各控制机件置于下列位置：

“AD⊥DC”：AC

“V/div”开关：0.02

Y轴“微调”：校准

“＋－×外接”：×外接

（2）将宽频带信号发生器的500 KHz正弦波信号输至Y轴输入端，调节宽频号信发生器输出幅度，使屏上显示的垂直幅度为6div。

（3）保持宽频带信号发生器输出幅度不变，记录信号频率在1MHz，2MHz，3MHz，4MHz，5MHz，8MHz，10MHz及100KHz、10KHz、100Hz和10Hz时屏上所显示的垂直幅度。低于10MHz所有频率，最大幅度与最小幅度之差不应＞3div；低于5MHz所有频率，最大幅度与最小幅度之差不应＞1.8div。否则可更换C_{22-19}数值，直至满足上述要求。

（4）将宽频带信号发生器输出1KHz正弦波输入外接X输入端，调节宽频带信号发生器输出幅度使屏上显示水平的幅值为6div，保持宽频带信号发生器输出幅度不变，记录在10Hz、100Hz、100KHz、200KHz时屏幕所显示的振幅值，其最大值与最小值之差不应＞1.8div。由于本机X轴响应较富裕，故一般不需要调整机内元件。

OSCILLOSCOPE MODEL ST16

The Oscilloscope Model ST16 is a small-sized and general-purpose oscilloscope which is capable of displaying waveforms up to 5 MHz, with maximum sensitivity 20 mV/div. Trigger sweep timebase with maximum sweep speed 100 ns-div. is adopted. It features compact size, light weight, low power consumption, novel design, easy carrying and simple operation. The provision of a built-in 100 mV calibration signal source is made in the oscilloscope for the calibrations of vertical sensitivity and horizontal sweep speed as well as the quantitative test of the signal under test.

The oscilloscope can be used for displaying general pulse waveforms, and is a useful test instrument for the maintenance and adjustments of electronic appliances such as television sets, amplifiers, receivers, etc., and is also suited for servicing on production lines in radio works. In addition, it can serve as a monitoring instrument for programmed machine tools and other machines.

I. TECHNICAL DATA

VERTICAL DEFLECTION

Bandwidth	DC: DC to 5 MHz, 3 dB DC to 10 MHz, 6 dB AC: 10 Hz to 4 MHz, 3 dB 10 Hz to 10 MHz, 6 dB
Deflection factor	0.02 to 10 V/div. in 1-2-5 steps, accurate within ± 10% at supply voltage 110/220V; fine adjusting ratio ⩾ 2.5:1
Input RC	1 MΩ// 30 pF; at probe (10:1): 10 MΩ// 15 pF
Max. input voltage	400 V combined DC + peak AC

HORIZONTAL DEFLECTION

Bandwidth	10 Hz to 200 KHz, 3 dB
Deflection factor	Within 0.5 V/div.
Input RC	1 MΩ//55 pF
Time base	0.1 μs/div. to 10 ms/div. in 1-2-5 steps, accurate within ±10% at supply voltage 110/220 V; fine adjusting ratio ⩾2.5:1
Trigger level (10 Hz-5 MHz)	Internal: ⩾1 div., external ⩾0.5 Vp-p
Trigger polarity	+ and —
Trigger sources	Internal, external, TV field

CALIBRATION SIGNAL

Waveform	Square wave
Amplitude	100 mV, accurate within ±5%
Frequency	The frequency of power supply, on which the oscilloscope is powered

CATHODE RAY TUBE

Type	8SJ 31J
Display area	6×10 div. (1 div. = 6 mm)
Persistence	Medium
EHV	1200 V

ENVIRONMENTAL & DIMENSIONAL DATA

Operating temperature	— 10 to + 40°C
Operating humidity	Within 85% (30°C)
Operating atmospheric pressure	750±30 mm Hg
Power supply	110/220 V ±10%, 50/60 Hz, consumption 55 VA
Dimensions	200 (H)×134 (W)×300 (L) mm
Weight	5.3 kg
Continuous duty	8 hr.

2. PANEL CONTROLS

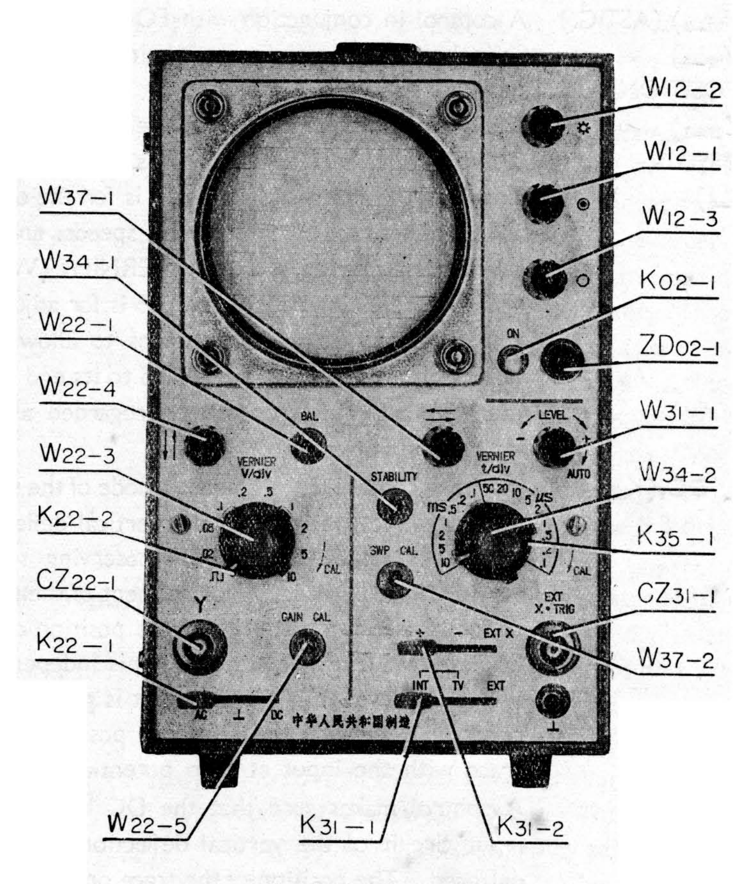


Fig. 1 Panel controls

ON (K_{02-1}) Switch on the mains switch, a red warning light immediately comes on. After a warm-up time, the instrument is ready to operate.

☼ (W_{12-2}) (INTENSITY) Turn the control clockwise to increase the brightness of the trace, counterclockwise to decrease till blank.

⊙ (W_{12-1}) (FOCUS)	Adjust the control to make the trace of the beam on the screen sharp and well-defined.
○ (W_{12-3}) (ASTIG.)	A control in conjunction with FOCUS.
↓↑ (W_{22-4}) (Y POSITION)	Shift the trace longitudinally, it being turned clockwise to shift the trace up.
Y (CZ_{22-1})	The input socket of the vertical deflection system.
VOLTS/DIV (K_{22-2})	0.02-10 V/div. in nine 1-2-5 steps. Square-wave singal on the first position "ʟп" is for the calibrations of sensitivities and sweep speeds, and for quantitative testing. Coaxial VERNIER (W_{22-3}) with fine adjusting ratio above 2.5 is for adjusting amplitude of displayed waveforms to allow easy observing. With VERNIER turned to its end CAL. the VOLTS/DIV figures can be regarded as the input sensitivities.
AC ⊥ DC (K_{22-1})	Selecting control of the coupling mode of the signal under test to the input of the vertical deflection system. DC: well suited for observing slowly varying signals. AC: DC component of the signal under test is blocked, so that the position of the displayed waveforms on the screen is independent of the DC level. "⊥": the input is grounded in order to determine the reference position of the trace with the input at zero potential.
BAL (W_{22-1})	A control makes sure that the DC level of the input circuit of the vertical deflection system is balanced. The position of the trace on the screen will vary longitudinally while VOLTS/DIV and VERNIER are adjusted if the input circuit is unbalanced.
GAIN CAL (W_{22-6})	With VERNIER set to CAL, the control is used for calibrating the input sensitivity by help of the built-in 100-mV square wave signal, square wave amplitude of 5 div. on the screen being as reference level.

⇆ (W_{37-1}) (X POSITION)	Shift the trace transversely, it being turned clockwise to shift the trace right.
TIME/DIV (K_{35-1})	0.1 μs/div. -10 ms/div. in sixteen 1-2-5 steps. Coaxial VERNIER control is for fine adjustment of sweep speed to ensure full coverage. With VERNIER (W_{34-2}), whose fine adjusting ratio above 2.5, turned to its end CAL, the TIME/DIV figures can be regarded as the sweep speed.
SWP CAL (W_{37-2})	The control is used for calibrating the sweep speed by help of the period of the built-in square wave, which depends direct on the frequency of the available mains supply. For example, assume the frequency of the mains supply is 50 Hz, then the period equals 20 ms. In this case, set TIME/DIV to the 2 ms/div. position and adjust SWP CAL untill a full cycle of waveform with width 10 div. is displayed. The width should be 8.3 div. if the mains frequency is 60 Hz.
LEVEL (W_{31-1})	The off position of the potentiometer at its clockwise end is AUTO, on which, in absence of signals, a bright baseline is displayed on the screen for the examination of the operation of the timebase unit.
STABILITY (W_{34-1})	This control is used for controlling the operation mode of the sweep circuit. The timebase unit is usually in triggered sweep by adjusting STABILITY in a manner as follows: (a) Set the coupling selector to the "⊥" and VOLTS/DIV to 0.02. (b) Turn STABILITY clockwise to its end, at which a trace should appear on the screen. Then turn slowly STABILITY till the trace disappears. At this time, the timebase unit comes into critical triggered sweep.
+ − **EXT X** (K_{31-2})	The control is used for selecting the polarity of the triggering slope. With the control set to

the position "EXT X", the socket EXT X TRIG serves as an external signal input terminal to the horizontal deflection system.

INT TV EXT (K_{31-1}) The control is used for selecting triggering source. On the position INT, the triggering signal is the signal under test from the vertical amplifier. On the position TV, the TV signal under test is through an integrating circuit taken out from the vertical amplifier to be triggering signal so that the TV signal displayed on the screen is in synchronization with the field frequency. On the position EXT, the triggering signal is external signal applied at the socket "EXT X TRIG". The external signal should be in a definite time relation with the signal under test.

EXT X TRIG (CZ_{31-1}) The input socket of external horizontal and triggering signals.

3. CIRCUIT DESCRIPTION

The oscilloscope consists of vertical amplifiers, trigger amplifier, shaper, sweep generator, horizontal amplifier, power supplies, c.r.t. and unblanking circuits and calibrator, as shown in the block diagram.

3.1 Power Supplies and Calibrator

The main parts of the power supplies and calibrator, except the power transformer B_{02-1}, are mounted on the two printed boards YB_1, YB_4. The power unit gives three d.c. supplies: ± 15 V regulated voltages and +250 V voltage which is associated with a resistance divider for +200 V and +60 V supplies as well as a −1200 V EHV supply for c.r.t. circuit.

−15V Regulated Power Supply

The 18 V, a.c. voltage, derived from the tappings 12 and 13 of the secondary winding of the transformer B_{02-1}, is through a bridge rectifier consisting of BG_{02-4} -BG_{02-7} applied to the series regulated circuit consisting of the regulation transistor BG_{02-9} and stabilizing transistor BG_{02-10}, on the output of which the −15 V regulated supply is given. A filtering

network is provided in the input circuit to the base of the regulation transistor and the stabilizing transistor serving as reference voltage in order to reduce the ripple in the voltage supply. In this case, the ripple involved after rectifying in the d.c. voltage is through the low-pass filter consisting of R_{02-6} and C_{02-4} to reduce the ripple appeared on the base and hence the output ripple on the emitter of the regulation transistor BG_{02-9}.

+15 V Regulated Supply

The 18 V a.c. voltage, derived from the tappings 14 and 15 or the secondary winding of the transformer B_{02-1}, is through a bridge rectifier consisting of BG_{02-11}-BG_{02-14} applied to the series regulated circuit consisting of the regulation transistor BG_{02-15} and reference stabilizing transistor BG_{02-16}, on the output of which the +15 V supply is given. The input voltage to BG_{02-16} is directly derived from the −15 V regulated supply, that is to say the reference voltage given by BG_{02-16} is twice regulated. As a result the +15 V supply has high stability and small ripple.

+250 V, +200 V, +60 V Supplies

The +260 V a.c. voltage, derived from the tappings 7,8,9, of the secondary of the winding of the transformer, is through a full-wave rectifier consisting of $BG_{02-1A-B}$ and $BG_{02-2A-B}$ and "π" filtering network consisting of C_{02-1}, C_{02-2A} and R_{02-3} to give the +250 V d.c. supply for the horizontal amplifier and the final output circuit of unblanking amplifier. The +250 V supply is via the dividing resistance R_{02-4} to give the +200 V supply for the common-grid amplifier of the vertical deflection system and the unblanking amplifier, and via the resistance R_{02-5} applied to the stabilizing diode BG_{02-3}, on the output of which a regulated +60 V supply is obtained for the pre-amplifying stages of the horizontal amplifier.

−1200 V EHV Supply

The 1100 V a.c. voltage is through a half-wave rectifier G_{12-1} and a divider fed to the c.r.t. circuit.

Calibrator

The 6.3 V a.c. voltage for tube filament, derived from the tappings 16 and 17 of the secondary winding of the transformer B_{02-1}, is through a dividing resistance R_{02-13} fed to the base of BG_{02-18} whose emitter is directly grounded and collector cut-off voltage is kept at about 6 V by the reference stabilizing transistor BG_{02-17}. The collector potential of BG_{02-18}

will transit alternately between the states of cut-off and saturation to perform clipping if the input voltage at its base is with a definite amplitude. In this way, square-wave, with constant amplitude independent of line frequency, is generated at the collector. The amplitude can be adjusted to exactly 100 mV by regulating the divider consisting of R_{02-12} and potentiometer W_{02-2}, for the purpose to calibrate the vertical sensitivity of the oscilloscope. And the sweep speed of the oscilloscope can also be calibrated with the period of the square-wave. W_{02-1} is used for adjusting the base bias of BG_{02-18}, thus ensuring symmetry of the square-wave signal.

3.2 C.R.T. Circuit and Unblanking Circuit

The −1200V EHV supply is through a divider consisting of R_{12-2}, W_{12-2}, R_{12-4}, W_{12-1} and R_{12-5} fed to various electrodes of the c.r.t. respectively. The anode of the rectifying tube G_{12-1}, the negative end of the EHV supply, is through the dividing resistance R_{12-2} and R_{12-6} connected to the control electrode of the gun, and then through the INTENSITY W_{12-2} and R_{12-3} fed to the cathode of the gun. The centre slider of the FOCUS W_{12-1} of the divider is connected directly to the first anode. The +200 V supply is through centre slider of the ASTIG control connected to the accelerating electrode between the control electrode and first anode. The potential differences of the second anode, first anode and control electrode in respect with the cathode are adjustable from +1200 to 1400V, +200V to 400 V and 0 to 100 V respectively by regulating W_{12-3}, W_{12-1} and W_{12-2}. The INTENSITY control W_{12-2} is adjusted to change the negative potential of the control electrode in respect with the cathode, thus controlling the beam. The beam is cut off when the control electrode potential is less than -75V. The FOCUS control W_{12-1} is adjusted to change the controlling of the beam by the electronic lens, obtaining well-defined trace on the screen. The ASTIG control is adjusted to change the potentials of the accelerating electrode and second anode so that electronic lens is fine regulated to have astigmatism of the beam eliminated. The INTENSITY, FOCUS and ASTIG controls should be adjusted in a concordant manner in order to have satisfactory trace displayed on the screen.

Unblanking Circuit

The tube G_{12-3} acts as the unblanking amplifier. The negative gate pulse, generated in the gate of the timebase unit during the forward sweep

is through the emitter follower BG_{34-4} and coupling capacitance C_{12-5} fed to the grid of the amplifier G_{12-3}. The negative pulse is after inverted and amplified and through the cathode follower coupling capacitance C_{12-3} fed to the control electrode. Under the applying of the high potential at the control electrode, the intensity is enhanced. The diode BG_{12-1} is used for protecting the cathode follower tube from damage due to too high voltage across the grid and cathode when switching on the power supply. The resistance R_{12-7} and diode BG_{12-2} play a role of improving the back front of the unblanking pulse.

3.3 Vertical Deflection System

The vertical amplifiers consist of two common-emitter difference amplifier stages and an emitter follower between them. The latter plays a role of buffer. A FET source follower serves as the input stage of the amplifiers to enhance the input impedance. The common emitter transistor amplifier and common grid tube amplifier in series connection form the output circuit to provide the driving signal of greater amplitude to the vertical deflection plates and to reduce the influence on common emitter circuit from Miller effect due to plate-grid capacitance.

The change-over switch in 1-2-5 steps K_{22-2C} and the gain calibration control both are provided in the vertical amplifier for adjusting the feedback between the difference amplifier stages, that is to switch and regulate the voltage gain of the amplifier. 10:1, 100:1 attenuator of RC frequency compensating type in the input circuit together with the change-over switch in 1-2-5 steps in first common-emitter amplifier stage form the VOLTS/DIV control K_{22-2}. A shift control is provided for shifting the trace longitudinaly. In addition, the signal under test after amplified is taken from the output of the second common-emitter amplifier stage by an emitter follower fed to the timebase unit as internal trigger source. The signal under test applied at the Y IN socket is through the coupling and sensitivity selectors K_{22-1} and K_{22-2} fed to the input source follower BG_{22-2}. With the coupling selector set to AC, the d.c. component of the signal under test is blocked by the coupling capacitance C_{22-1}. In order to avoid the low frequency distortion and sag caused by the coupling capacitance, it is advisable to set the coupling selector to the DC position. In this case, if there is d.c. component in the signal under test, then the waveform displayed on the

screen will have a deviation from the reference line in direct proportion to the d.c. component. The sensitivity selector is provided to facilitate observing the signal under test. 10:1, 100:1 attenuators, serving as the selector, are RC attenuating networks with frequency compensation. The attenuating networks are essentially resistance divider in low frequency region, and essentially capacitance divider in high frequency region. The frequency characteristics can be properly compensated by adjusting the adjustable capacitors C_{22-3} and C_{22-7} of the capacitance divider to have equal capacitance impedance ratio and resistance ratio. C_{22-2} and C_{22-6} in parallel with the attenuating network is used to have predetermined input capacitance for all the setting of the sensitivity selector so that the RC constant of the probe is kept invarying wherever the sensitivity selector is set when the probe is used.

FET source follower serves as the input stage, ensuring high input impedance. In order to protecting the source follower from damage due to too large input signal, a parallel current-limited network consisting of C_{22-9} and R_{22-6} is connected in series in its gate circuit and the collector junction of BG_{22-1} acts as a clamp diode. The d.c. balance transistor BG_{22-3} and BG_{22-2} form a symmetrical balance circuit to reduce the drift caused by temperature and supply voltage variations.

The d.c. potential at the gate of BG_{22-3} can be adjusted by the centre slider of the potentiometer W_{22-1} and through its source fed to the base of BG_{22-5} to make the amplifier be in satisfactory d.c. balance. The voltage gain of the first common emitter difference amplifier BG_{22-4} and BG_{22-5} is controlled by the feedback resistances R_{22-18}, R_{22-19} and R_{22-20} between the two emitters and changed over in 1-2-5 steps with the VOLTS-DIV control. The input sensitivities are selected by the VOLTS-DIV control in conjunction with the input attenuating network. The emitters of BG_{22-4} and BG_{22-5} are through potentiometer W_{22-2} and resistances R_{22-16} and R_{22-17} respectively supplied, W_{22-2} being provided to adjust the emitter resistances of BG_{22-4} and BG_{22-5} for ensuring equal d.c. potentials at two collectors. The signals after amplified taken from the two collectors are through the emitter follower BG_{22-6} and BG_{22-7} and resistances R_{22-27} and R_{22-28} fed respectively to the two bases of second common emitter amplifier. R_{22-27} and R_{22-28} together with R_{22-30} and potentiometer W_{22-3} form a resistance divi-

der, W_{22-3} playing a role of the VERNIER control. By virtue of the low output impedance of the emitter follower, the influence caused by capacitance variation due to W_{22-3} on the frequency response of the amplifier is negligible. The RC network consisting of feedback resistance R_{22-33} between the two emitters of BG_{22-8} and GB_{22-9} and R_{22-34}, C_{22-13} and C_{22-19} is used for adjusting the voltage gain and improving the HF phase characteristics. The signal derived from the collector after amplified is fed to the mixed common emitter-common grid difference amplifier consisting of BG_{22-11}, BG_{22-12}, G_{22-1A} and G_{22-1B}. The two grids of the common-gird amplifier are through C_{22-16} grounded so that a good isolation between the cathode-grid input and the plate-grid output is obtained, resulting in eliminating the influence on the input circuit by Miller effect due to the plate-grid capacitance. In this way, the high frequency characteristics is improved. The driving voltage of greater amplitude called for the vertical deflection plates can be obtained from at the plate output of G_{22-1A} and G_{22-1B}, because the common emitter amplifier has high current gain and the collector current after amplified is superposed on the plate current to flow through the load resistances R_{22-50} and R_{22-51}. The compensating network consisting of potentiometer W_{22-6} and resistance R_{22-46}, R_{22-47} and C_{22-15} connected between the two emitters of the common emitter amplifier is used for calibrating the total voltage gain of the amplifier and improving the transient characteristics. A two-gang potentiometer W_{22-4A} and W_{22-4B} is provided in the input circuit base of BG_{22-11} and BG_{22-12} to adjust the injecting current into the two bases so that d.c. output potential between the two plates is correspondingly changed to shift the trace on the screen longitudinally.

The collector output signal of the second common-emitter difference amplifier BG_{22-10} is in part taken out through the emitter follower BG_{22-10} to be fed to the timebase unit as the internal trigger source with the source selector provided.

3.4 Horizontal Deflection System

The horizontal deflection system consists of trigger amplifier, shaper, sweep generating and control circuits and horizontal amplifier. The sweep signal after amplified is fed to the horizontal deflection plates as time base to display the waveform in function of time.

The sweep signal is generated when the time capacitance controlled by a thyristor is through the sweep gate charged by a constant current source and is discharged through the thyristor. The sweep signal derived from the time capacitance after amplified, through the hold-off circuit, is used for controlling the trigger pulse driving the gate. As a result, the output amplitude of the sweep voltage and the initial level of sweep both are kept constantly. Adjusting the sweep speed is obtained by switching the time capacitances with the TIME/DIV control and changing the current-limit resistance of the constant current source. The voltage of the constant current source is regulated to have the sweep speed adjusted fine. The negative gate pulse derived from the sweep gate is through the emitter follower and after amplified used as unblanking signal. All the units of the horizontal deflection system are described as follows.

Tirgger Amplifier and Shaper

The internal trigger signal derived from the emitter follower BG_{22-10} of the vertical deflection system or the external trigger signal applied at the front panel socket CZ_{31-1} is through the trigger source control K_{31-1b} fed to the gate of the source follower BG_{31-3}. The FET source follower input stage of the trigger amplifier plays roles of enhancing input impedance and buffering between the trigger source and trigger amplifier. The RC parallel network consisting of C_{31-2} and R_{31-2} and the clamping diodes BG_{31-1} and BG_{31-2} connected in series in the gate input circuit of BG_{31-3} are used for protecting the source follower from damage due to too large input signal. In order to have equal triggering both from positive and negative slopes of triggering signal, the output trigger signal at the source of BG_{31-3} is through the coupling capacitance and the trigger polarity selector fed to a base of the difference amplifier of BG_{31-4} and BG_{31-5}. At this time, the other base of the difference amplifier is through the switch K_{31-2d} connected to the dividing network consisting of R_{31-19}, R_{31-20} and the TRIGGER LEVEL control W_{31-1}. When setting to the positive slope, the trigger signal is applied to the base of BG_{31-4}, and the base of BG_{31-5} is connected to the d.c. dividing network of the TRIGGER LEVEL control, the TRIGGER LEVEL being adjusted to have a d.c. reference level, which corresponds to the triggering level at the base

of BG_{31-4}, at the base of BG_{31-5}. When the trigger signal rises at a point, whose level is about the d.c. reference level at the base of BG_{31-5}, the collector current of BG_{31-4} rises rapidly and its voltage falls correspondingly. Under the applying of this voltage variation, Schmidt circuit consisting of BG_{31-6} and BG_{31-7} will provide a output of negative rectangular pulse at the collector of BG_{31-7}. The negative rectangular pulse is through the differential network consisting of C_{31-6} and C_{31-17} and the clapper of diodes BG_{31-8} and BG_{31-9} shaped into negative trigger pulse, which is taken out from the coupling capacitance C_{31-7}, for triggering the sweep gate. When the trigger source control is set to the TV position, the trigger signal derived from the source follower BG_{31-3} (i.e. the TV signal from the vertical deflection system) is through the integrating network consisting of R_{31-4} and C_{31-8} to separate the field synchronous signal which is in turn through the coupling capacitance C_{31-4} fed to the difference amplifier to be shaped, differentiated and clapped.

Sweep Generating and Control Circuits

The sweep gate for controlling the operation of the thyristor BG_{34-6} is Schmidt circuit consisting of BG_{34-2} and BG_{34-3}. Before pulse comes on, if the STABILITY control is in triggered state, then BG_{34-2} is in conducting state and BG_{34-3} is in cut-off state. In this case, the collector of BG_{34-3} is at high potential which in turn through the dividing network consisting of R_{34-10}, R_{34-11}, R_{34-12} and the diode BG_{34-5} causes BG_{34-6} to come in critical saturation state, and the time capacitances C_{35-7}-C_{35-13} are in low potential. When the negative triggering pulse derived from the coupling capacitance C_{31-7} of the trigger circuit comes at the base of BG_{31-2} and if the amplitude of the triggering pulse is large enough to trigger the gate, the collector of BG_{34-3} is from high potential turned to low potential to cause the thyristor BG_{34-6} to be cut off. In this case, the time capacitance is through constant current transistor BG_{34-7} charged to cause the potential of the latter to rise linearly, resulting in forming the forward stroke of sewep. The rising speed of the sweep voltage depends on the time capacitances C_{35-7}-C_{35-13} and the current-limit resistances R_{35-1}-R_{35-4} in series connected to the constant current transistor, with a potentiometer, which is used to change the voltage across the emitter current-limit resistance by regulat-

ing the d.c. potential of the base of the constant current transistor, provided as the fine control of the sweep speed. The potential variation across the time capacitance, through the two stages of emitter followers consisting of BG_{34-8} and BG_{34-9}, falls into two ways. In one way, it is through the dividing network consisting of R_{34-24} and R_{34-25} and the trigger selector K_{31-2b} fed to the horizontal amplifier, the output of which is applied to the horizontal deflection plates as timebase. In another way, it through the resistance divider of the emitter of BG_{34-9} and the isolation diode BG_{34-10} applied to the hold-off capacitances C_{35-1}-C_{35-6} to charge. At this time, the potential of the hold-off capacitances rises with the forward stroke till the bias at the base of BG_{34-2} begins to reverse the gate circuit, that is BG_{34-2} conducts and BG_{34-3} cuts off, whereas the thyristor BG_{34-6} begins to conduct again when the collector of BG_{34-3} jumps from low potential to high potential. At this time, the time capacitance is immediately through the collector of the thyristor discharged to form the backward stroke and to cause the isolation diode BG_{34-10} to be cut off through the two stages of emitter followers. The potential at the hold-off capacitances will be through BG_{34-2} discharged till the isolation diode BG_{34-1} begins to conduct that in turn casues the potential at the hold-off capacitances to keep constant for a time before next stroke of sweep begins when the negative trigger pulse derived from C_{31-7} comes on. The amplitude of the sweep voltage can be adjusted by W_{34-3} of the emitter resistance divider of BG_{34-9}. The duration of the backward stroke of sweep depends on the time capacitances and the internal resistance during conduction of collector-to-emitter of the thyristor. The hold-off circuit with discharge time constant larger than the duration of the backward stroke which causes the bias of the base of BG_{34-2} to be controlled by the pontential of the hold-off capacitances, is adopted in order to cause the gate circuit to be inoperative to the trigger pulse from the trigger circuit before the time capacitances are fully discharged. If not, the initial levels of various strokes of sweep are different so that the waveforms displayed on the screen wobbles horizontally.

If the STABILITY control W_{34-1} is adjusted away from the triggered state and set to the most negative position, or if the LEVEL control W_{31-1} is clockwise turned to its stop and the grounding of W_{34-1} is cut off by

the gang switch, then the sweep circuit becomes to be in auto state, in case of which the gate circuit automatically reverses in absence of trigger signal at the base of BG_{34-2}, as the potential of the hold-off capacitance will do not cause the isolation diode BG_{34-1} to conduct and continue falling during discharge.

In addition to the use for controlling the thyristor, the negative output pulse of the sweep gate is through the emitter follower BG_{34-4} and capacitance C_{12-15} fed to the unblanking signal amplifier.

Horizontal Amplifier

The horizontal amplifier consists of two stages of direct-coupling tube difference amplifiers. The sweep signal derived from the sweep generating and control circuits, or the external signal applied at the input socket can be through the selector K_{31-2b} and K_{31-2c} fed to the grid of G_{37-1A}. G_{37-1B} plays a role of d.c. balance, its grid potential can be adjusted by the horizontal shift control W_{37-1} and the divider consisting of R_{37-5} and R_{37-6} to make the potentials at the two plates relatively changed for the purposes of balance and shift. The voltage gain is controlled by W_{37-2} and R_{37-9} connected in series in the two cathodes and adjusted by W_{37-2} to calibrate the sweep speed. Capacitances C_{37-2} and C_{37-3} are H.F. compensating ones for improving the response of the amplifier. The diodes BG_{37-1} and BG_{37-2} are used to protect the amplifier tube from damage due to too large grid-cathode potential when switching on the power supply.

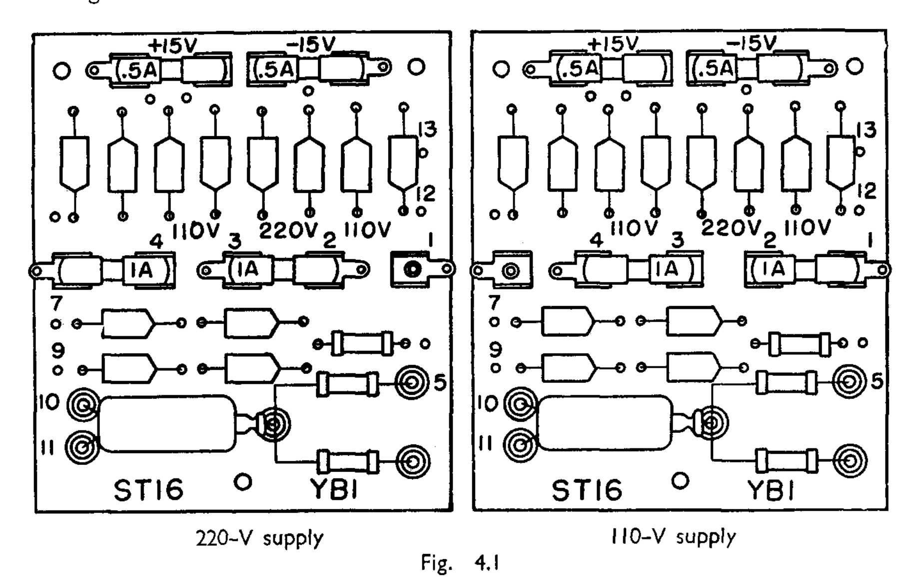
4. OPERATING INSTRUCTIONS

4.1 Points to Watch before Operation

It is recommended for the operators to familiarize themselves with the contents of this Operation Manual, especially the sections Technical Data, Panel Controls and Operating Instructions in order to correctly and effectively utilize the oscilloscope.

Make sure that the available power supply is in conformity with the rated supply of the oscilloscope. The supply voltage of the oscilloscope is set to 220V before despatching ex-works. If the available supply voltage is 110V, remove the rear board and reconnect the fuses BX_{02-2}

and BX_{02-1} on the printed board YB I on the bottom in a manner as shown in Fig. 4.1.



220-V supply   110-V supply

Fig. 4.1

4.2 Preliminary Check

It is advisable before first use or when the instrument is reput in use after long-term storage to make the preliminary check as follows.

(1) Set the all controls in a manner as listed in Table 4.1.

Table 4.1.

Controls	Position to be set	Controls	Position to be set
☼	Counter-clockwise stop	AC ⊥ DC	⊥
⊙	Half-way	LEVEL	AUTO
○	Half-way	TIME/DIV	2 ms
↓↑	Half-way	VERNIER	CAL
⇆	Half-way	+ − EXT X	+
VOLTS/DIV	⎍	INT TV EXT	INT
VERNIER	CAL		

(2) Switch on the power supply, a warning light comes on immediately and allow a while for warm up.

(3) Adjust the INTENSITY control "☼" and not synchronous square wave calibration signal should be displayed on the screen at this time.

(4) Turn the LEVEL control counter-clockwise away from the AUTO position till the waveform displayed comes into synchronization. With the waveform positioned in the center of the screen, the vertical amplitude of the waveform should be about 5 div. and the width of its period about 10 div (the line frequency 50 Hz) or 8.3 div (the line frequency 60 Hz) in this case if the oscilloscope is in normal order of operation (see Fig. 4.2).

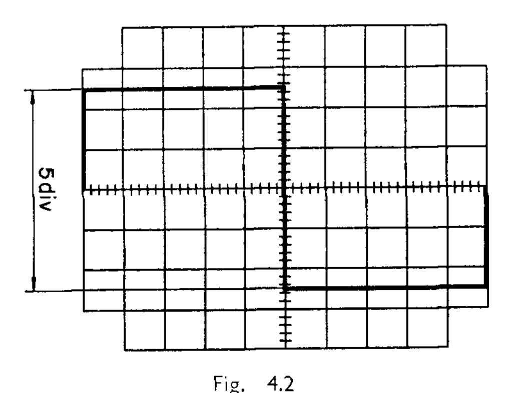


Fig. 4.2

4.3 Preliminary Calibrations

(1) After completing the above-mentioned preliminary check and more some minutes, the BALANCE control W_{22-1} is so adjusted that the VOLTS/DIV control is changed over without vertical shifting of the waveform displayed.

(2) The accelerating voltage–1200 V depends on the line voltage to a definite extent. When the line voltage deviates from the rated voltage supply 220 or 110 V of the oscilloscope the deflection sensitivity of the c.r.t. will be directly influenced, thereby resulting in greater errors in the vertical sensitivity and the sweep speed. Therefore, the preliminary calibrations of the vertical gain (W_{22-5}) and sweep speed (W_{37-2}) should be respectively done before use so that the vertical amplitude of the calibration signal is exactly 5 div and the period width exactly 10 div or 8.3 div.

4.4 Measuring Voltage

After the preliminary calibrations described in the section 4.3, the voltage amplitude of the signal under test can be quantitatively measured with the oscilloscope.

Measuring d.c. Voltage

If there is dc level in the signal under test and if the dc level is required to be measured, a reference level, usually the ground potential of the oscilloscope should be utilized for the measurement purpose. The procedures are as follows:

(1) Set the input coupling selector to "⊥", the LEVEL control to AUTO till a trace appears on the screen. And set the VOLTS/DIV and TIME/DIV controls to proper positions respectively according to the amplitude and freduency of the signal under test and then adjust the vertical shift control "↑↓" to have the trace placed on a specific reference position (0 V) on the reticle.

(2) Set the input coupling selector to the "DC" position and connect the signal under test directly or via probe into the input socket CZ_{22-1}. And adjust the LEVEL control till a stationary waveform is obtained on the screen.

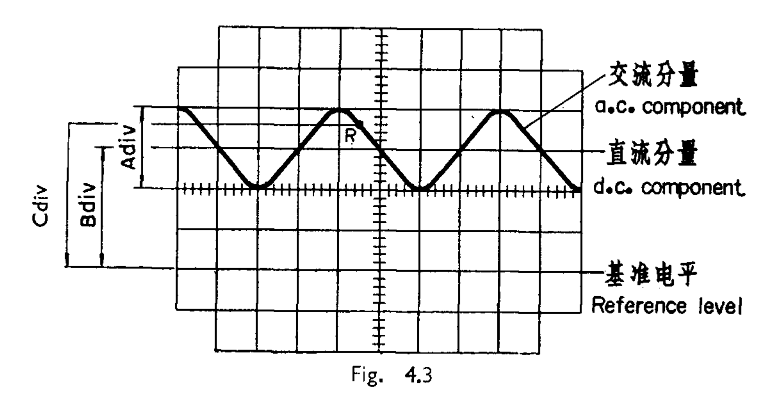


Fig. 4.3

(3) In accordance with the cross-hairs of the reticle, the following readings in div. can be taken down: the ac component (peak-to-peak) A of the signal under test, the dc component B and the voltage C of a specific point R of the signal under test in respect to the reference level. If the VOLTS/DIV control is set to 0.2 V/div. and the 10:1 probe is used, then the various voltages of the signal under test is obtained as follows:

ac component Vp-p = 0.2 V/div × A div × 10 = 2A (Vp-p)
dc component V = 0.2 V/div × B div × 10 = 2B V
Instantaneous voltage at point R V = 0.2 V/div × C div × 10 = 2C V

Measuring ac Voltage

Generally, the peak-to-peak value of the ac component is directly measured. The signal under test is usually through a d.c. block capacitance at input to have the dc component to be separated as the signal under test superimposed with dc component often is over the effective dynamic range of the amplifier so that lower sensitivity has to be set, thereby reducing the measuring accuracy. Therefore, the ac component is measured in a manner as follows, but the measurement of signal under test of lower frequency is carried out in the same manner as that for the measurement of dc component, because an additional error will be introduced in the measurement due to larger capacitive impedance of the coupling capacitance at lower frequency.

(1) Set the input coupling selector to "AC", the VOLTS/DIV and TIME/DIV controls to proper ranges according to the amplitude and frequency of the signal under test. And connect the signal under test directly or via probe to the input of the vertical oscilloscope and adjust the LEVEL control till stationary waveform appears on the screen, as shown in Fig 4.4.

(2) In accordance with the cross-hairs of the reticle, the peak-to-peak reading D in div is taken down. If the VOLTS/DIV control is set to 0.1 V/div and the 10:1 probe is used, then the peak-to-peak value is

Vp-p = 0.1 V/div × D div × 10 = D (Vp-p).

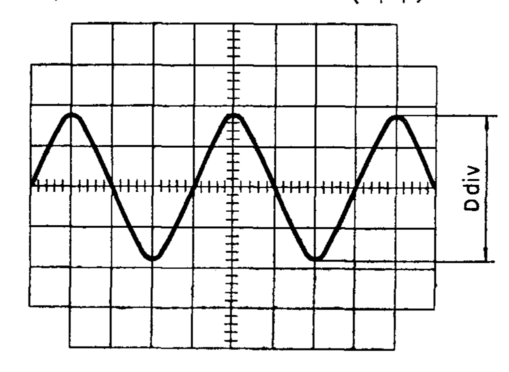


Fig. 4.4

4.5 Time Measurement

After completing the calibration of sweep speed as described in the section 4.3, the interval between arbitrary two points of the signal under test can be quantitatively measured in a manner as follows.

(1) Set the TIME/DIV control to proper range in accordance with the repetition frequency of the signal under test or the interval between the two specific points P and Q of the waveform so that the waveform between the two points occupies the screen to the greatest extent for higher measuring accuracy, as shown in Fig. 4.5.

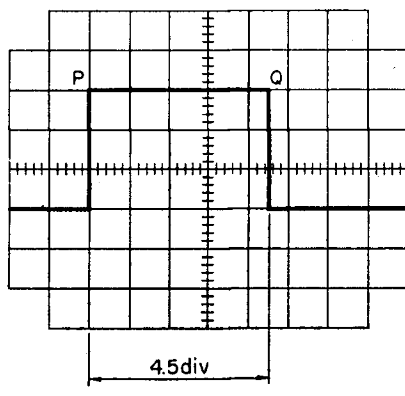


Fig. 4.5

(2) In accordance with the cross-hairs of the reticle, the reading D in div. of the interval of the two points P and Q is taken down. If the TIME/DIV control is set to 2 ms/div and D=4.5 div, then the interval t is

$t=2\ \text{ms/div} \times D\ \text{div} = 2\ D\ \text{ms} = 9\ \text{ms}.$

4.6 Risetime Measurement

After completing the calibration of sweep speed as described in the section 4.3, the risetime of pulse front edge can be measured in a manner as follows.

(1) Set the VOLTS/DIV control to a proper range according to the amplitude of the signal under test and adjust the VERNIER control till the waveform with amplitude exactly 5 div appears on the screen.

(2) Adjust the LEVEL and "⇄" controls and set the TIME/DIV control to a proper range according to the risetime till the waveform appears on

the screen as shown in Fig. 4.6.

(3) In accordance with the cross-hairs of the reticle, the reading D in div of the risetime of the front edge, which is defined between two levels 10% and 90% of the amplitude of the pulse under test, is taken down. If the TIME/DIV control is set to 0.1 μs/div and D=1.6 div, then the risetime t_r is

$$t_r=\sqrt{t_1^2-t_2^2}=\sqrt{(1.6\times 100)^2-70^2}\simeq 144 \text{ ns}$$

Where t_1 is the risetime of the waveform on screen;
t_2 is the risetime of the oscilloscope, about 70 ns

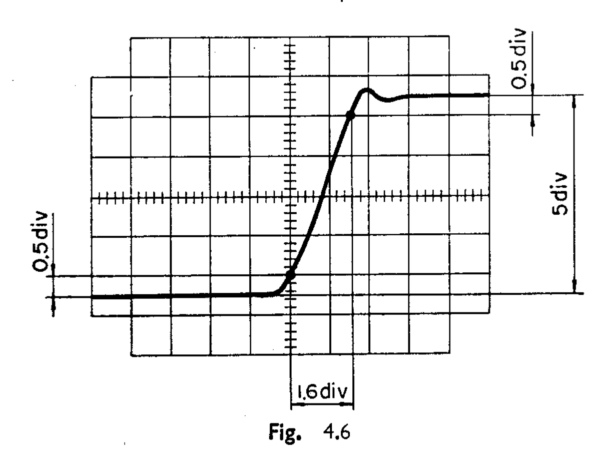


Fig. 4.6

4.7 Frequency Measurement

The repetition frequency of the signal under test can be measured in the same manner as that for the time measurement described in the section 4.5, but the measuring result is converted into the frequency by calculating with the measuring accuracy depending on the time measuring accuracy. For example, if the period of the signal under test is measured to be T=4 μs, then the frequency is

$$f=\frac{1}{T}=\frac{1}{4\times 10^{-6}}=0.25\times 10^6=250\,(\text{KHz})$$

The frequency can also be measured by Lissajou's figures with help of a signal generator of known frequency in a manner as follows, with the measuring accuracy direct depending on the frequency accuracy of the generator.

(1) Connect the signal under test f (y) to the input socket of the oscilloscope and the signal from the generator f(×) to the socket "EXT X".

(2) The frequency of signal under test f(y) X is calculated according to the number of loops of Lissajou's figures and the frequency of f(×), Lissajou's figures are shown in Fig. 4.7 where the frequency ratio is f (y): f (x).

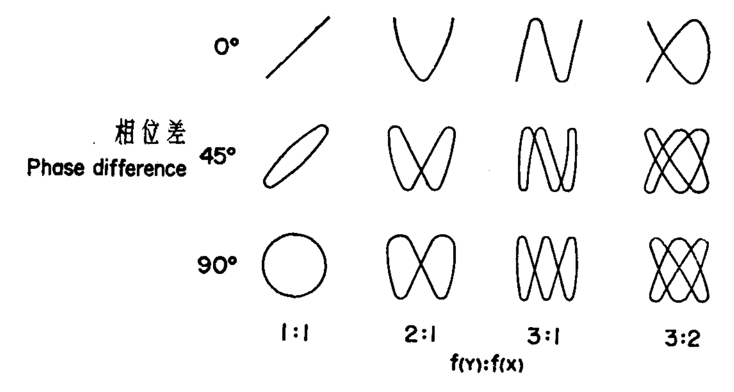


Fig. 4.7

4.8 Phase Measurement

The phase shift of a network, e.g. lagging phase of sinusoidal wave after passing through an amplifier, can be measured with the oscilloscope in a manner as follows.

Method A

(1) Set the trigger source selector K_{31-1} to EXT, connect a lead signal A to the vertical input socket CZ_{22-1} and external trigger input socket CZ_{31-1} respectively. And then adjust the TIME/DIV, VERNIER and LEVEL controls till the period of the waveform displayed on the screen is exactly 9 div, thus the horizontal cross-hairs corresponding directly to the phase of the signal under test, i.e. 360°/9 div = 40°/div.

(2) The abscissa of the specific point P of the lead signal A is taken down. Leaving the settings of the controls in the step (1) (trigger source selector, TIME/DIV, VERNIER, LEVEL, "⇄"). Connect lagging signal B instead of lead signal A to the vertical input socket and take down the abscissa of the specific point p' of the waveform of the lagging signal, as shown in Fig. 4.8.

(3) The phase shift between these two signals is obtained by calculating according to their distance D in div as follows:

$$\phi = D\ \text{div} \times 40°/\text{div} = 40°D$$

If D=2.25 div, then $\phi = 90°$.

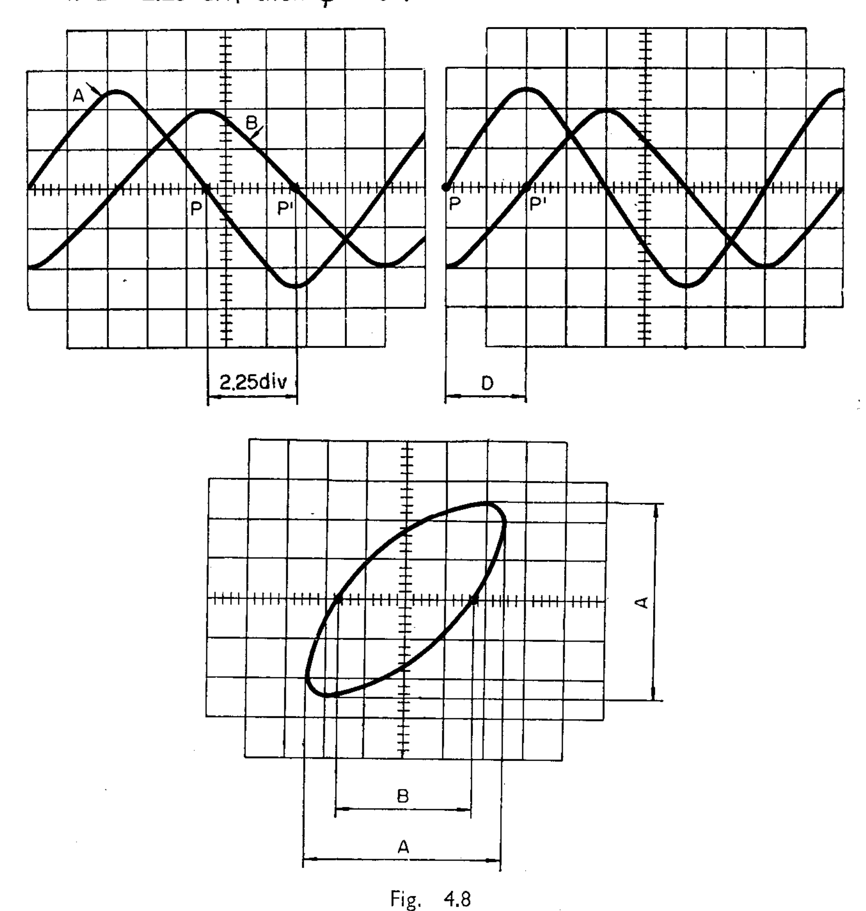


Fig. 4.8

Method B

The procedures are similar essentially to those of the method A. But the period of the waveform displayed on the screen is now taken as T in div (not as exactly 9 div). If the distance between the points P and P' is D in div (see Fig. 4.8), then the phase shift ϕ of these two phases is

$$\phi = \frac{D}{T} \times 360°.$$

Method C: Lissajous figures

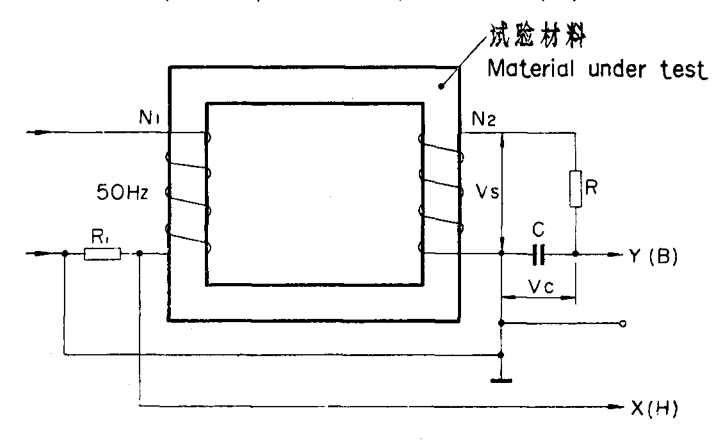
(1) Set the trigger source selector K_{31-2} to EXT X and connect a lead signal A to the EXT X socket. And adjust the amplitude of the signal so that the abscissa of the waveform is A in div. Then connect the lagging singal B to the vertical input socket, and adjust the VOLTS/DIV and VERNIER controls till the amplitude of the waveform is also exactly A in div (see Fig. 4.8 C).

(2) If the distance of the two intersecting points of the waveform and the X axis is B in div, then the phase shift between the two signals is

$$\phi = \arcsin \frac{B}{A}.$$

4.9 Hysteresis Loop Display

The oscilloscope can be used as a X-Y tracer for displaying the B-H curves of magnetic materials to compare their performances. The measuring method is as shown in Fig. 4.9. The voltage across the resistance R_1 corresponds directly to the magnetic field intensity H as the current flowing through the primary winding N_1 is proportional directly to H. This voltage is applied to the horizontal system of the oscilloscope. The voltage V_s induced across the secondary winding N_2 is proportional directly to the magnetic flux density B. Therefore, if $R \geqslant \frac{1}{\omega C}$ in the integrating network consisting of R and C, then the voltage V_c across the capacitance C corresponds to B. This voltage is applied to the vertical system. In this way, the hysteresis loop will be displayed on the screen.



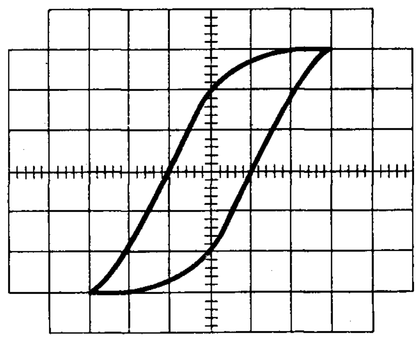


Fig. 4.9

5. ADJUSTMENTS

It is essential to do the adjustments described below after the oscilloscope has been used for long time or repaired greatly. The following instruments are required in the adjustments, and their specifications are listed in Table 5.1.

Table 5.1.

Serial No.	Instrument	Main specifications
1	Wideband signal generator	Bandwidth 10 Hz-20 MHz, output amplitude above 500 mV, with output distortion indicator
2	Squarewave generator	Amplitude 0-100 V ±1%, frequency 1 kHz
3	Timemark generator	0.1 μs-10 ms ±1%
4	Multimeter	0-50 V, 0-500 V, 0-2500 V ±2.5%, internal resistance 20 kΩ/V
5	AC voltmeter	0-300 V, 1%

It is imperative for assuring the adjusting accuracy that the instruments are powered by stabilized 220 V supply voltage, with the AC voltmeter as a monitor.

5.1 DC Power Supply Adjustments

There are following dc supplies in the oscilloscope: regulated ± 15 V supplies, unregulated +250 V supply and +200 V supply from RC divider, regulated +60 V supply and − 1200 V EHV. Their permissible ranges are listed in Table 5.2.

Table 5.2

Supplies	Point at which test to be done	Permissible range	Remarks
+ 250 V	$YB3_{(1)}$	≃ 260 V	
+ 200 V	$YB2_{(1)}$	≃ 200 V	
+ 60 V	$YB3_{(2)}$	55-60 V	Regulated
+ 15 V	$YB4_{(1)}$	15-16.5 V	Regulated
− 15 V	$YB4_{(7)}$	− 15—16.5 V	Regulated
− 1200 V	$G_{12-2(2)}$	≃ − 1200 V	

5.2 Vertical Amplifier Balance Adjustment

Pair selection has been done for the transistors of the vertical amplifiers by the manufacturers. Therefore, the faulted transistors should be disconnected pair by pair and the replacement should be done by pair selection (mainly for β value), thereby ensuring satisfactory balance.

The vertical amplifier should be adjusted in a manner as follows:

(1) The relative controls are set as follows:

+ − EXT X: EXT X

Y VERNIER: CAL

⇆: Half way

↑↓: Half way

Allow a few minutes for warm up and the spot will come on the

horizontal centre of the screen.

(2) Turn the Y VERNIER control W_{22-1} so that the VOLTS/DIV control is turned without shifting the spot. And turn the balance potentiometer W_{22-2} inside the case so that the spot is positioned on the vertical centre of the screen. These adjustments are repeated many times till the spot does not shift whatever the VOLTS/DIV control is set to and the vertical shift control is turned to its half way to have the spot on the centre.

5.3 Vertical Attenuator and Probe Compensation Adjustments

(1) The settings of the related controls are as follows:

TIME/DIV: 0.2 ms
VERNIER: CAL
+ − EXT X: +
INT TV EXT: INT
AC ⊥ DC: AC
Y VERNIER: CAL

(2) Connect output squarewave of 1 kHz from a squarewave generator to the vertical input and adjust the LEVEL control to have the waveform triggered. Adjust the amplitude of squarewave and the VOLTS/DIV control and related elements till the waveform as shown in Fig. 5.1, which is critically compensated, is displayed on the screen. The adjustments are listed in Table 5.3.

Table 5.3

Setting of VOLTS/DIV control	Output amplitude of squarewave generator	Amplitude of waveform displayed on screen	Element to be adjusted
0.02	0.1 V	≃ 5 div	—
0.2	1 V	≃ 5 div	C_{22-3}
2	10 V	≃ 5 div	C_{22-7}

Under compensation   Critical compensation   Over compensation

Fig. 5.1

(3) Connect the probe to the vertical input and connect the probe to the output squarewave of 1 kHz of the squarewave generator. Adjust the capacitance and other elements inside the oscilloscope till the critical compensation for the waveform displayed on the screen is obtained, as shown in Table 5.4.

Table 5.4

Setting of VOLTS/DIV control	Output amplitude of squarewave generator	Amplitude of waveform	Element being adjusted
0.02	1 V	≃5 div	Probe capacitance
0.2	10 V	≃5 div	C_{22-2}
2	100 V	≃5 div	C_{22-6}

5.4 Vertical Input Sensitivity and Calibration Signal Adjustments

(1) Make sure that the power supply for the oscilloscope under adjustment is kept in range of $220 \pm 2\%$, and set all the controls as follows:

TIME/DIV: 0.2 ms
VERNIER: CAL
+ − EXT X: +
INT TV EXT: INT
AC⊥DC: AC
Y VERNIER: CAL
VOLTS/DIV: 0.02

(2) Connect the squarewave signal of 100 mV to the vertical input and adjust the GAIN CAL control till the waveform amplituide displayed on the screen is exactly 5 div and set the VOLTS/DIV control to "⊓⊔" and the TIME/DIV control to 5 ms, leaving the settings of other controls. And then adjust W_{02-2} till the waveform amplitude is exactly 5 div.

(3) Reset the TIME/DIV control to 0.2 ms and adjust the output amplitude of the squarewave generator and the VOLTS/DIV control till the amplitude of the squarewave displayed on the screen is in conformity with that listed in Table 5.5.

Table 5.5

Output amplitude of squarewave generator	Setting of VOLTS/DIV control	Waveform amplitude displayed on screen	Accuracy
100 mV	0.02	5 div	Calibration
250 mV	0.05	,,	± 10%
500 mV	0.1	,,	,,
1 V	0.2	,,	,,
2.5 V	0.5	,,	,,
5 V	1	,,	,,
10 V	2	,,	,,
25 V	5	,,	,,
50 V	10	,,	,,

5.5 Sweep Speed Adjustment

(1) Make sure that the power supply for the oscilloscope under adjustment is kept in range of 220 V ±2% and set all the controls as follows:

TIME/DIV control: 1 ms
VERNIER: CAL
LEVEL: counter-clockwise stop
+ − EXT X: +
INT TV EXT: INT
AC ⊥ DC: AC

(2) Set the time mark generator to 1 ms and connect its output to the vertical input of the oscilloscope under adjustment and adjust the VOLTS/DIV VERNIER controls till the pulse amplitude displayed on the screen is 2 to 3 div. And then turn clockwise the LEVEL control to have the sweep triggered.

(3) Adjust the SWEEP CAL control till the trace of 10 div in length contains 11 peaks (i.e. 10 preiods). Then adjust the potentiometer W_{34-3} to have the trace been 11 div-11.5 div in length.

(4) Set the TIME/DIV control and the period of the time mark generator as listed in Table 5.6 till the number of peaks contained in the trace of 10 div in length and its accuracy are in conformity with that listed in Table 5.6.

Table 5.6

Setting of time mark generator	Setting of TIME/DIV control	Waveform: peaks/10 div	Accuracy
10 ms	10 ms	11	±10%
	5 ms	6	,,
	2 ms	3	,,
1 ms	1 ms	11	Calibration
	0.5 ms	6	±10%
	0.2 ms	3	,,
100 μs	0.1 ms	11	,,
	50 μs	6	,,
	20 μs	3	,,
10 μs	10 μs	11	,,
	5 μs	6	,,
	2 μs	3	,,
1 μs	1 μs	11	,,

(5) The TIME/DIV control should be set to 0.1 μs and the time mark generator set to 0.1 μs when the adjustment is done on the sweep

speeds 0.5 μs, 0.2 μs and 0.1 μs. In this case, C_{35-7} is adjusted to have 11 peaks contained in the trace of 10 div in length. And then set the TIME/DIV control to 0.2 μs to have 19-23 peaks (that is to say accuracy of ±10%) contained in the trace of 10 div in length.

(6) Set the TIME/DIV control to 0.5 μs and the time mark generator to 1 μs. At this time, 6 peaks should be contained in the trace of 10 div in length, accuracy of ±10% being ensured.

5.6 Frequency Response Adjustment

(1) Set all the controls as follows:

AC ⊥ DC: AC

VOLTS/DIV: 0.02

Y VERNIER: CAL

\+ − EXT X: EXT X

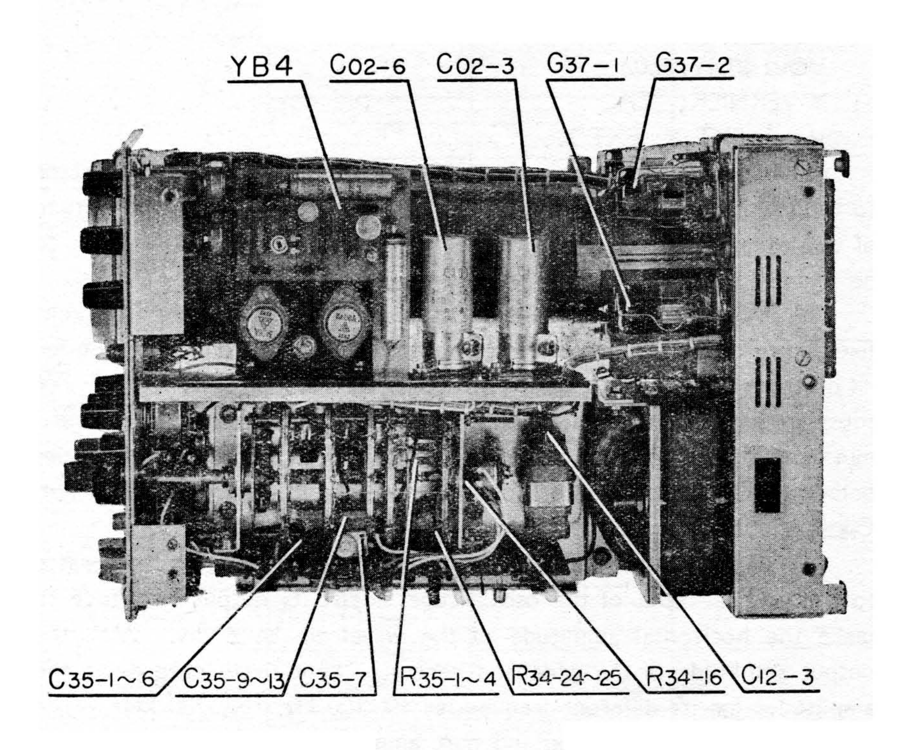
(2) Connect the sine signal of 500 kHz from the wideband generator to the vertical input of the oscilloscope, and adjust the output amplitude of the wideband generator to make the amplitude of the waveform to be 6 div.

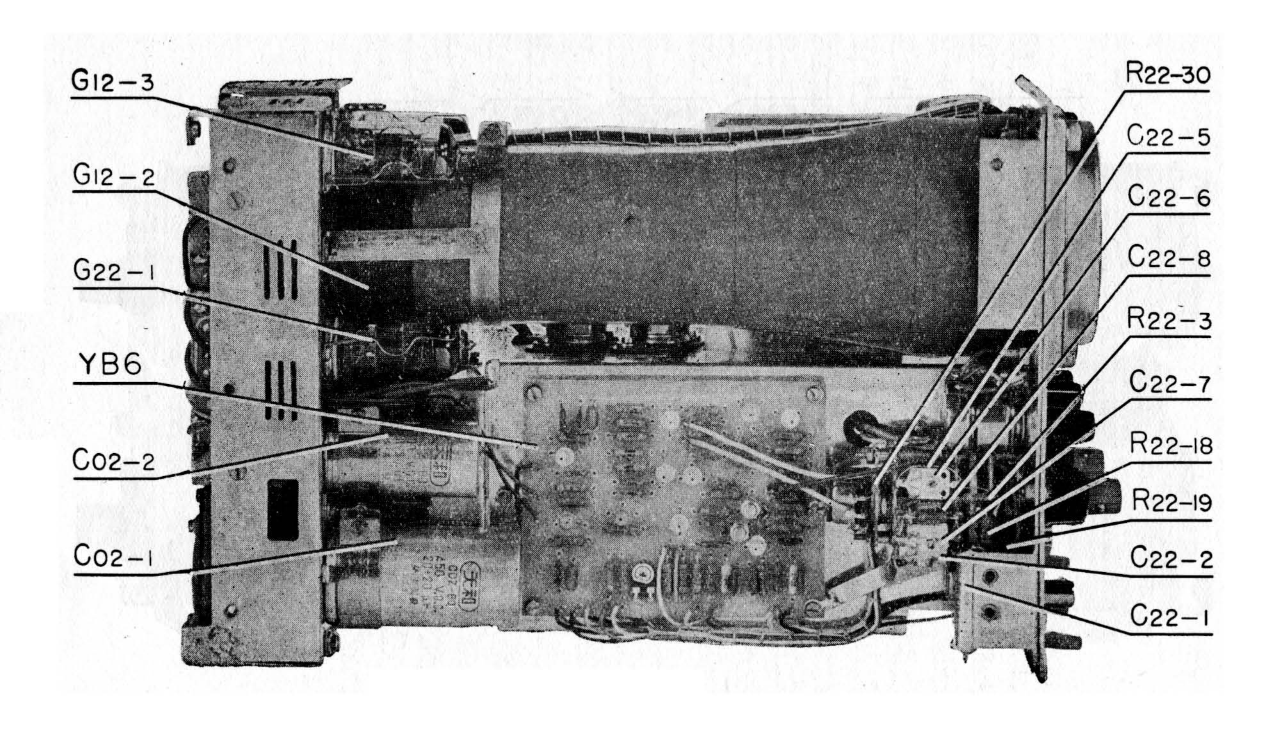
(3) With the output amplitude of the wideband generator kept fixed, note down the amplitudes of waveform displayed on the screen for its different frequencies 1,2,3,4,5,8,10 MHz, 100, 10 kHz, 100, 10 Hz. For those frequencies below 10 MHz, the difference between the max. and min. amplitudes should be not greater than 3 div. For those frequencies below 5 MHz, the difference should be not greater than 1.8 div. If not, C_{22-19} should be replaced.

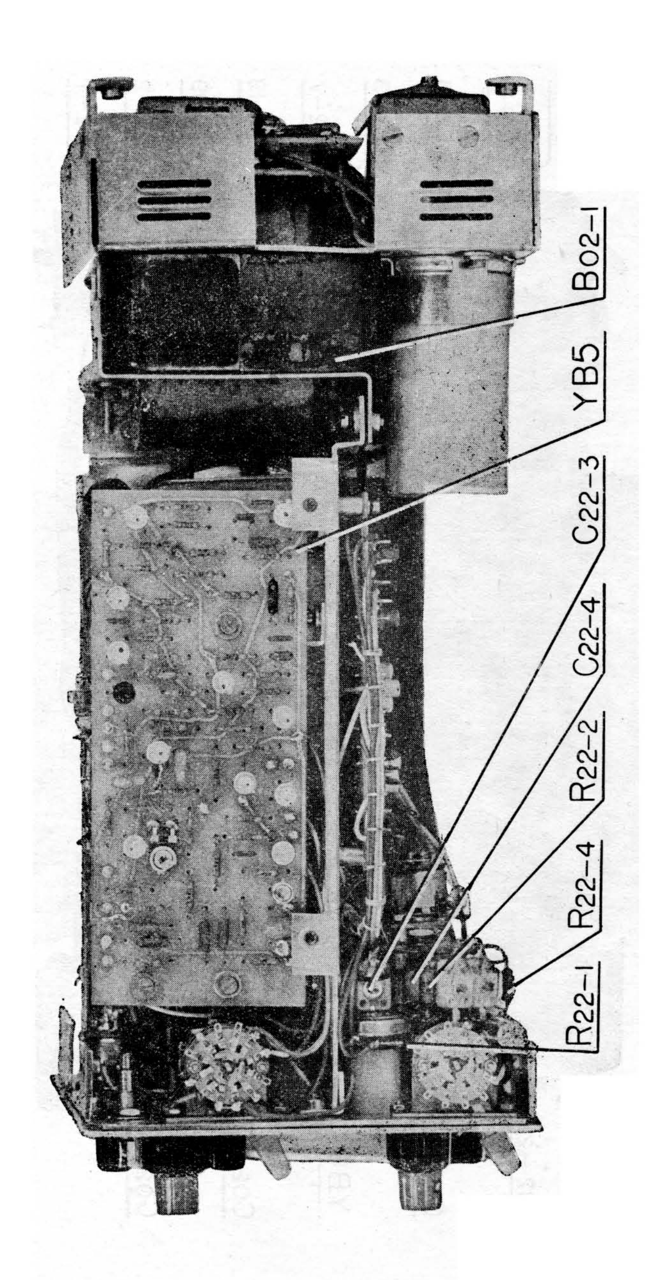
(4) Connect the sine signal of 1 kHz from the wideband generator to the vertical input of the oscilloscope, adjust its output amplitude to make the horizontal amplitude of the waveform be 6 div. With the output amplitude of the wideband generator kept fixed, note down the amplitudes for its different frequencies 10, 100 Hz, 100, 200 kHz. The difference between the max. and min. amplitudes should be not greater than 1.8 div. The adjustments of elements is usually not required to be done in the horizontal system as the horizontal response of the oscilloscope is well sufficient.

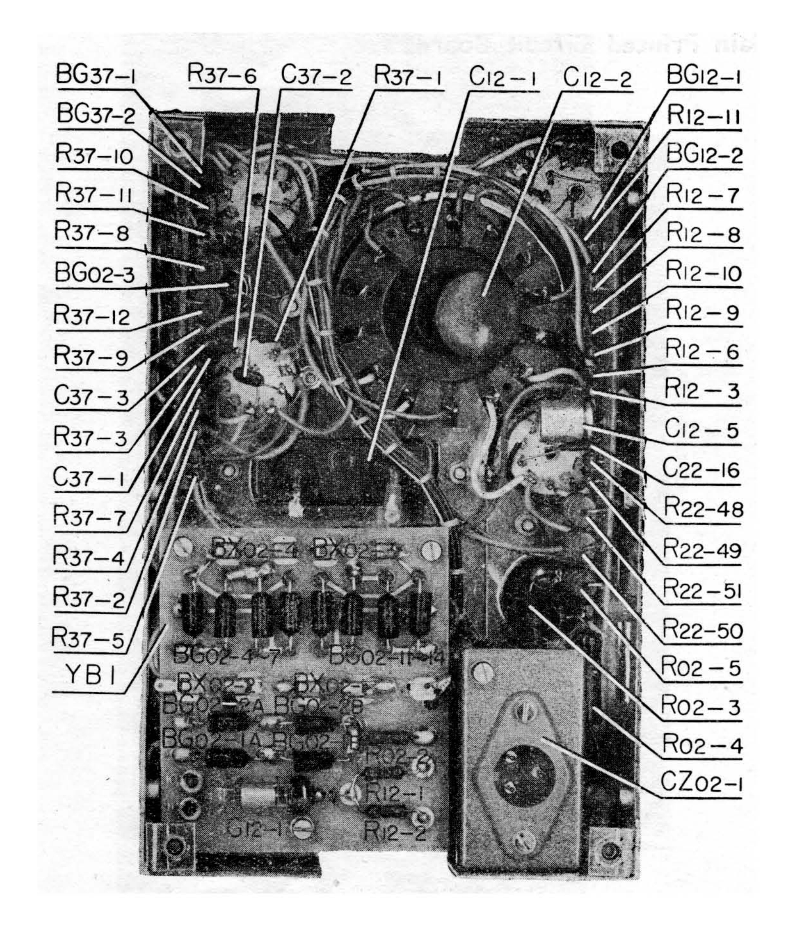
整机元件排列

Parts Layout



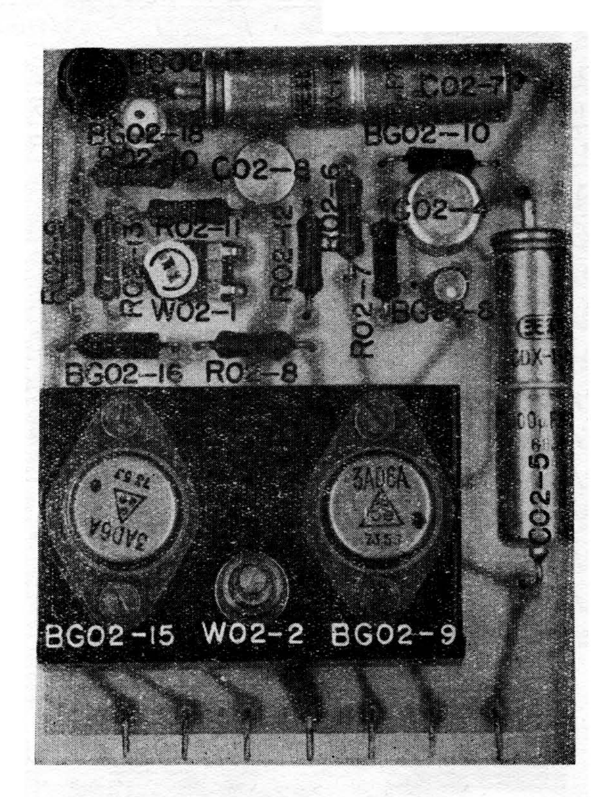

G12-3
G12-2
G22-1
YB6
C02-2
C02-1
R22-30
C22-5
C22-6
C22-8
R22-3
C22-7
R22-18
R22-19
C22-2
C22-1


R22-1
R22-4
R22-2
C22-2
C22-4
C22-3
YB5
B02-1



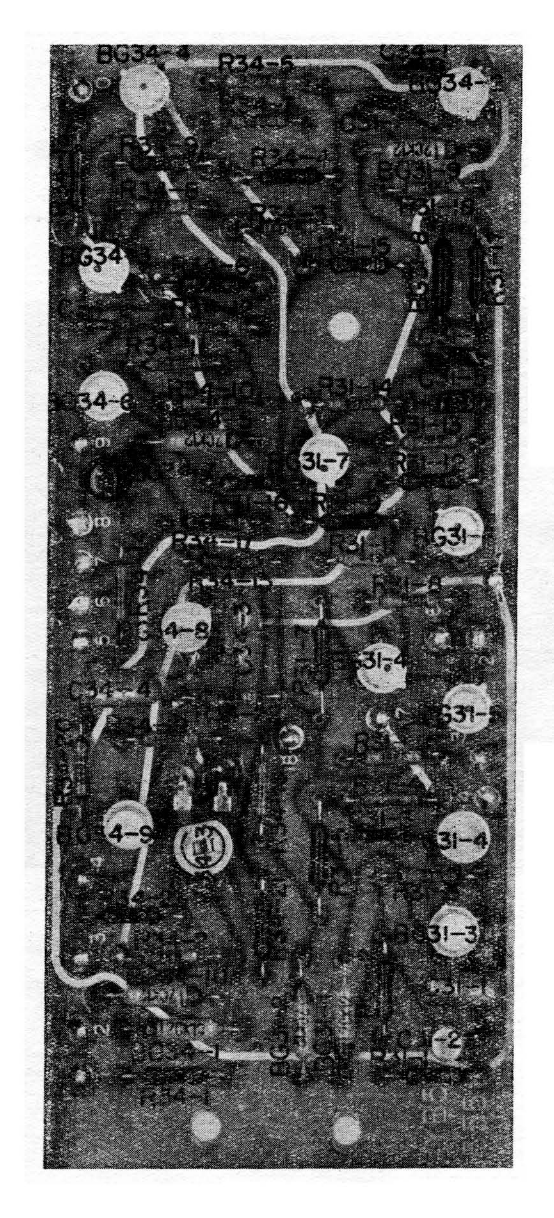
BG37-1
R37-6
C37-2
R37-1
C12-1
C12-2
BG12-1
BG37-2
R12-11
R37-10
BG12-2
R37-11
R12-7
R37-8
R12-8
BG02-3
R12-10
R37-12
R12-9
R37-9
R12-6
C37-3
R12-3
R37-3
C12-5
C37-1
C22-16
R37-7
R22-48
R37-4
R22-49
R37-2
R22-51
R37-5
R22-50
YB1
R02-5
R02-3
R02-4
CZ02-1

主要印制板元件排列
Main Printed Circuit Boards

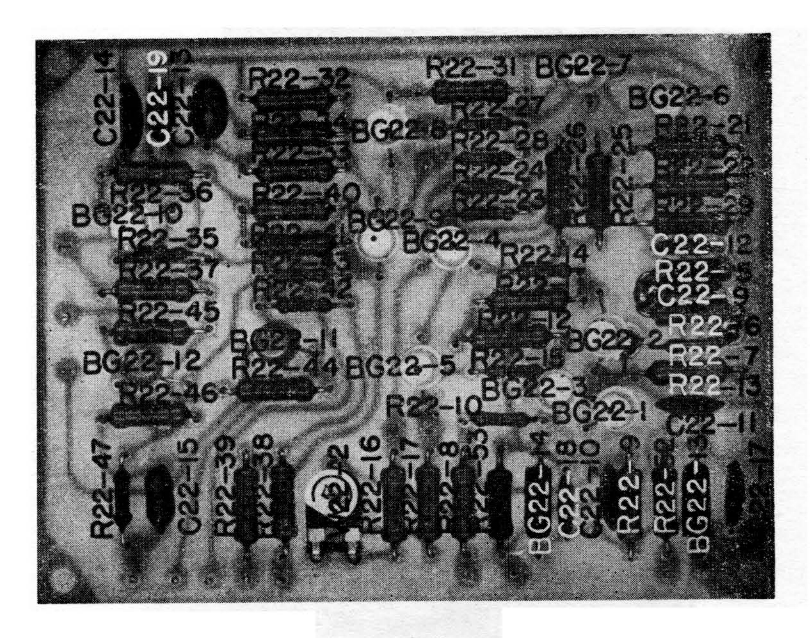


±15V 稳 压 电 源 及 校 准 信 号

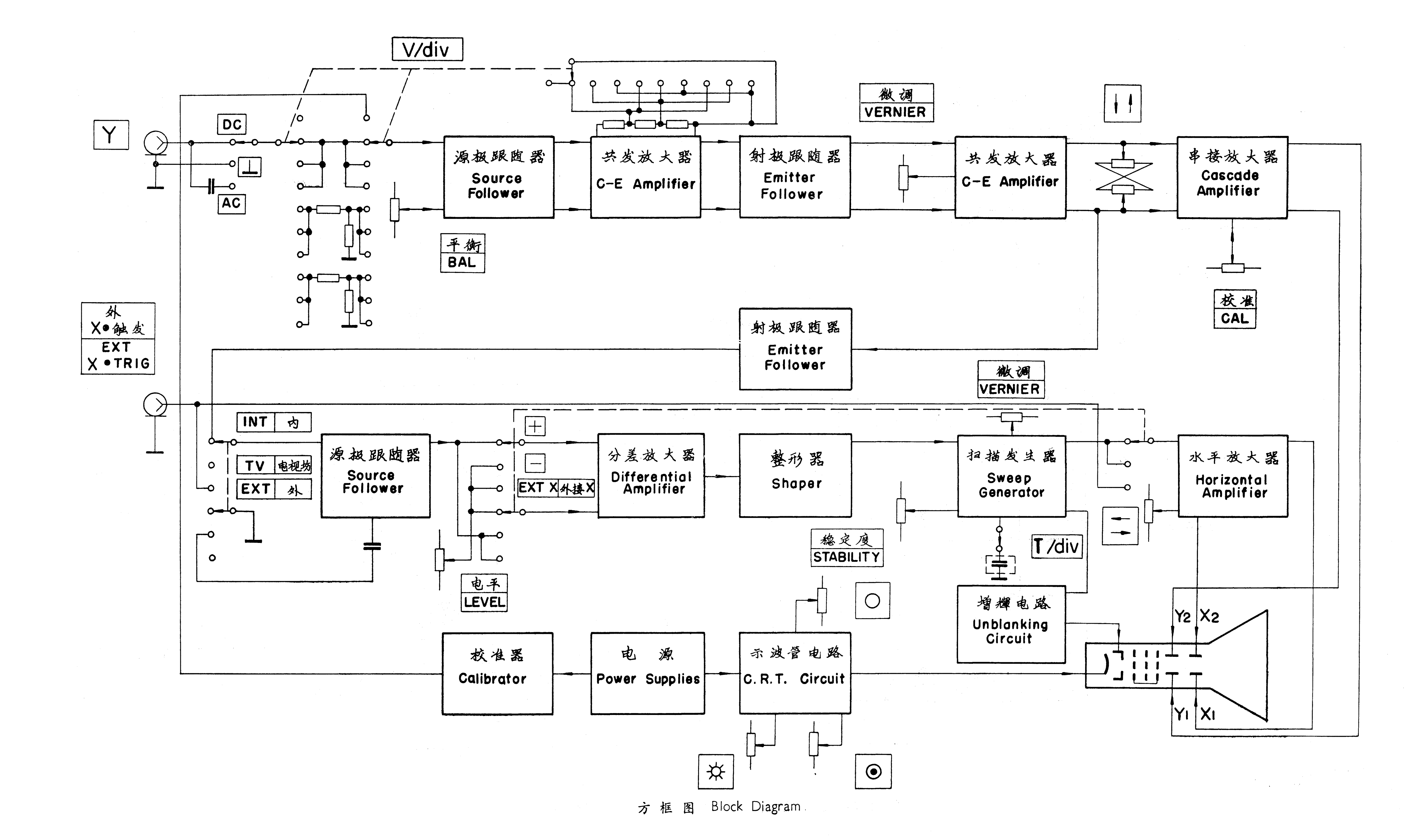
±15 V Regulated Supplies and Calibration Signal



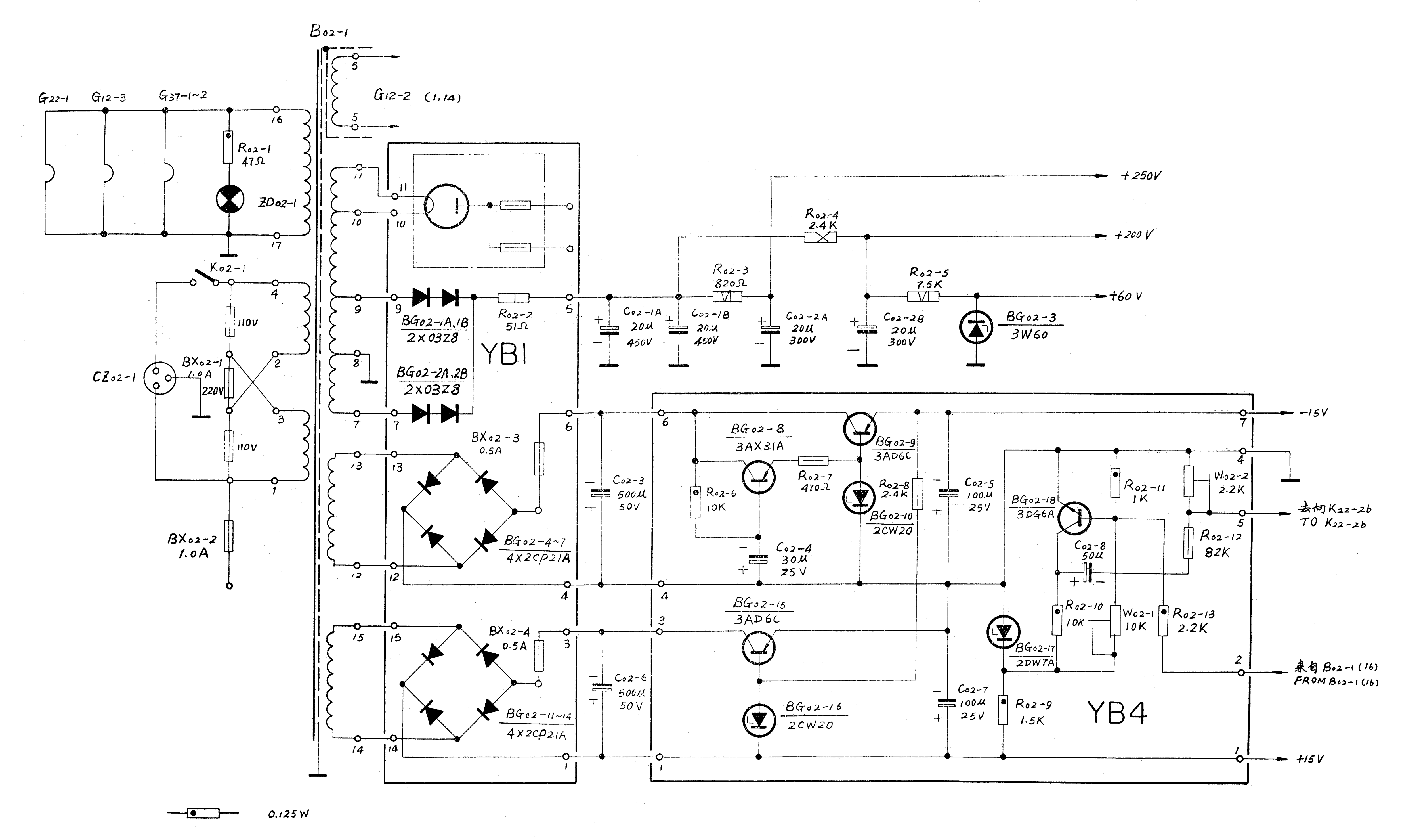
触发及扫描发生器 Timebase Unit



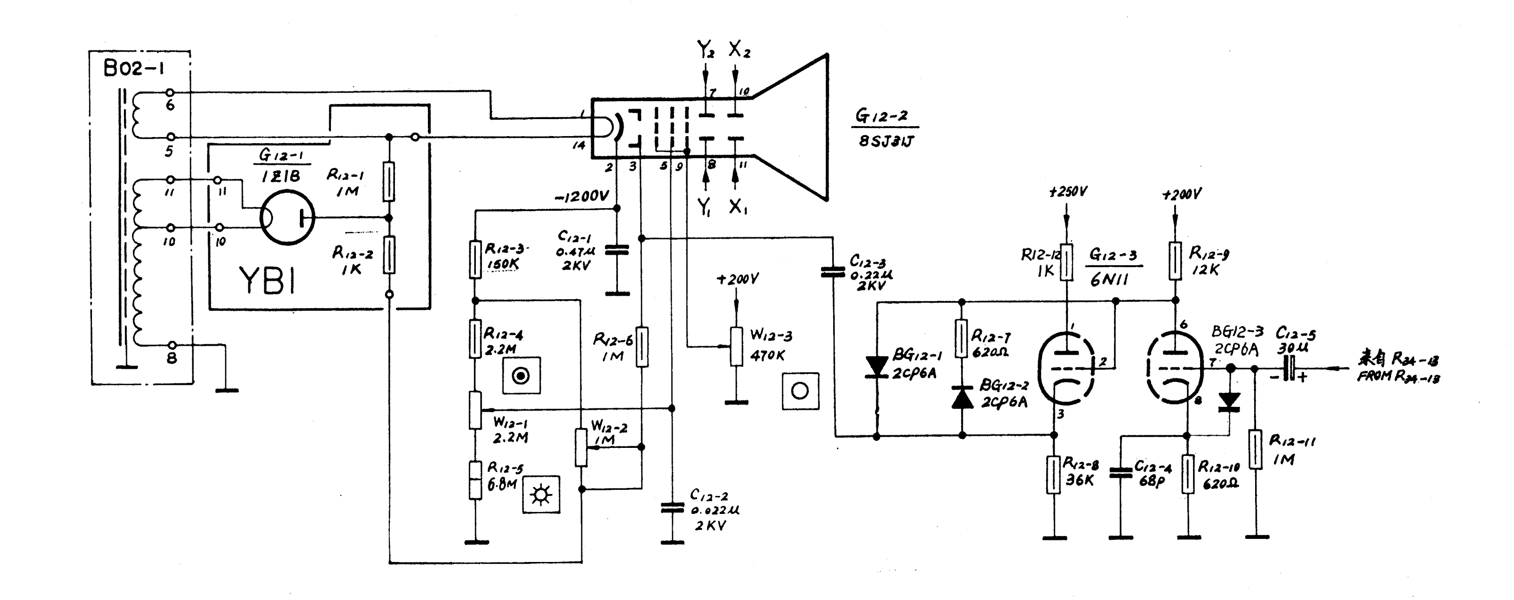
垂直放大器
Vertical Amplifier



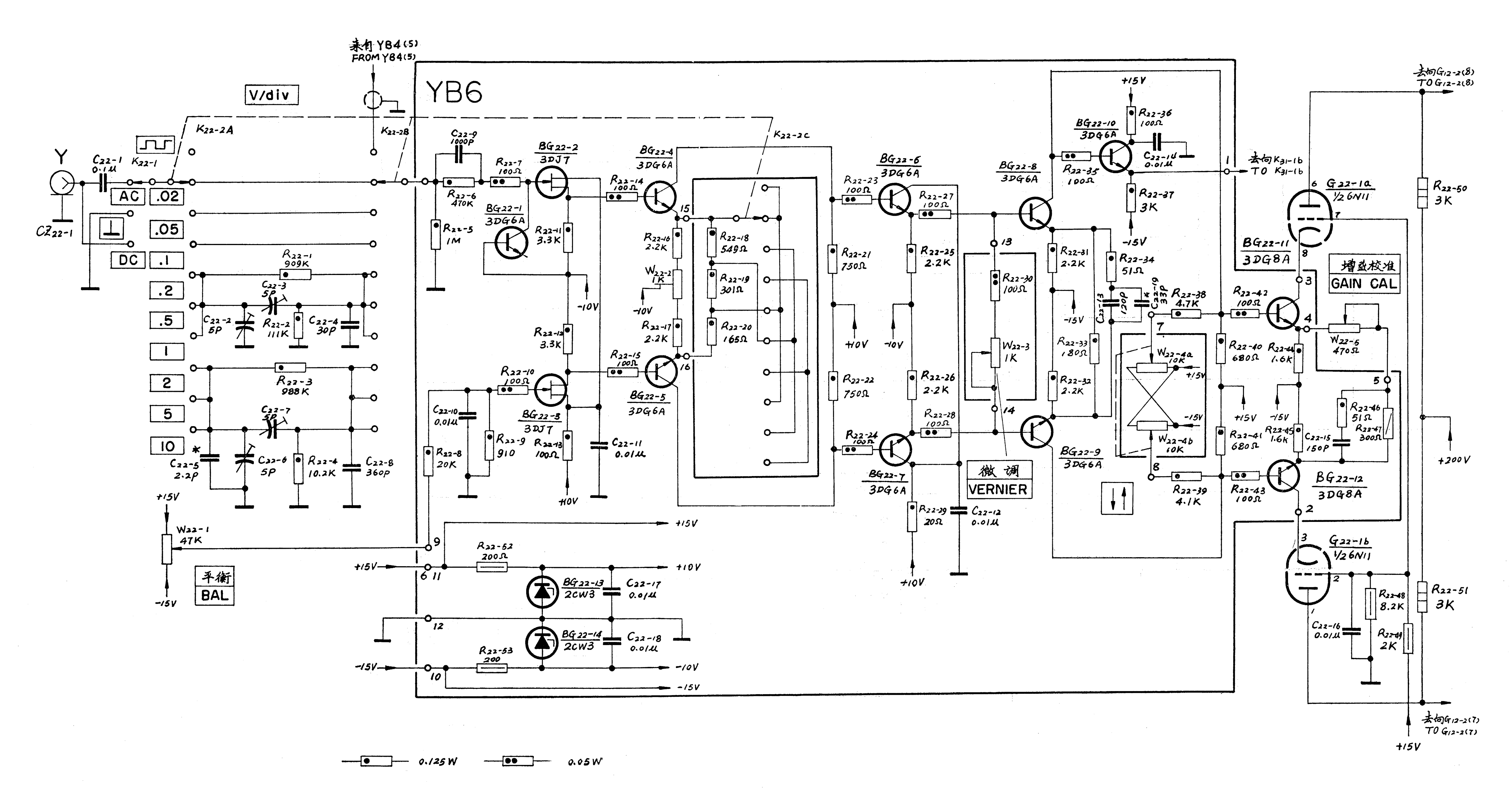
方 框 图 Block Diagram



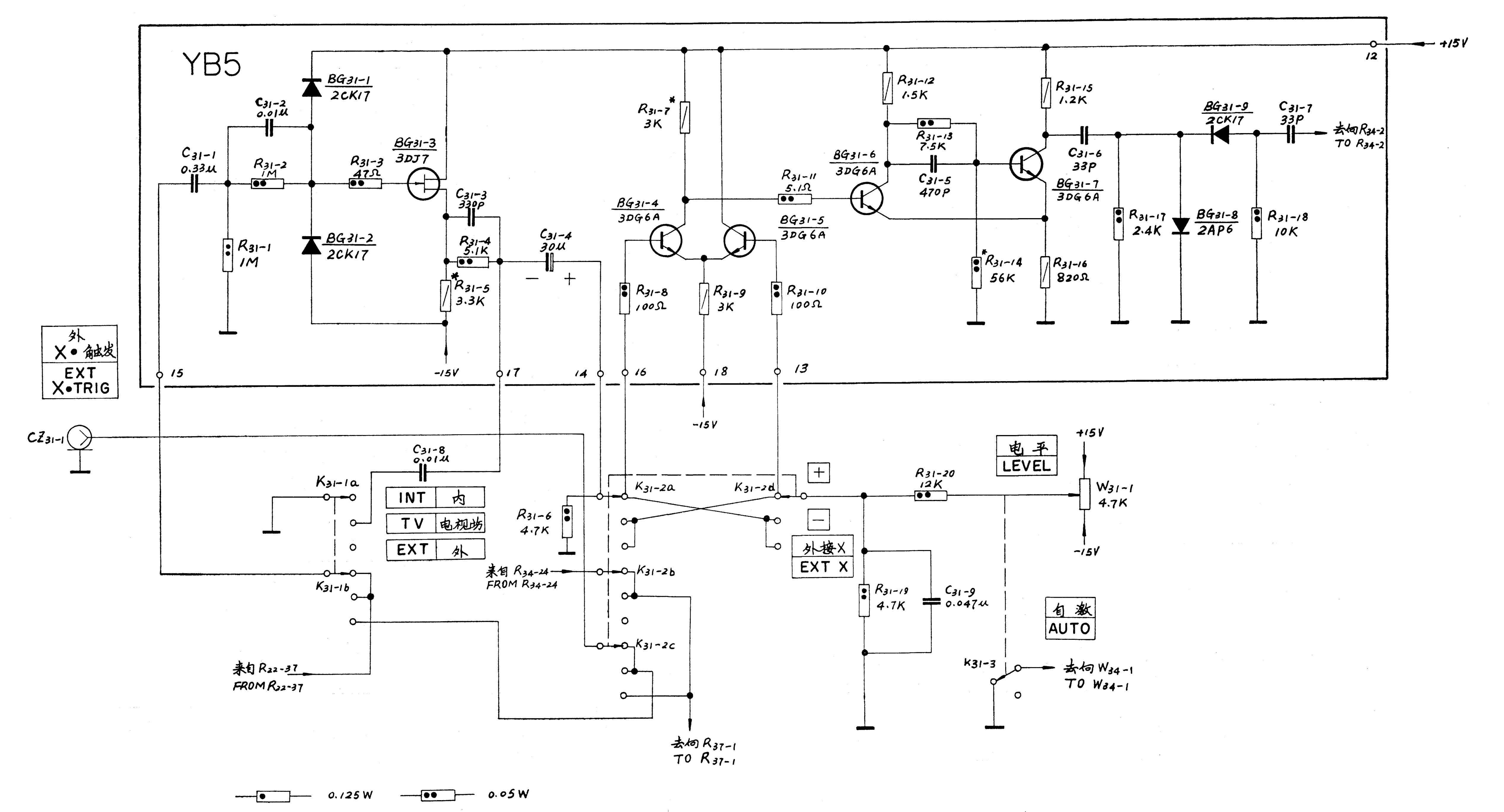
电 源 和 校 准 信 号 Power Supplies and Calibrator



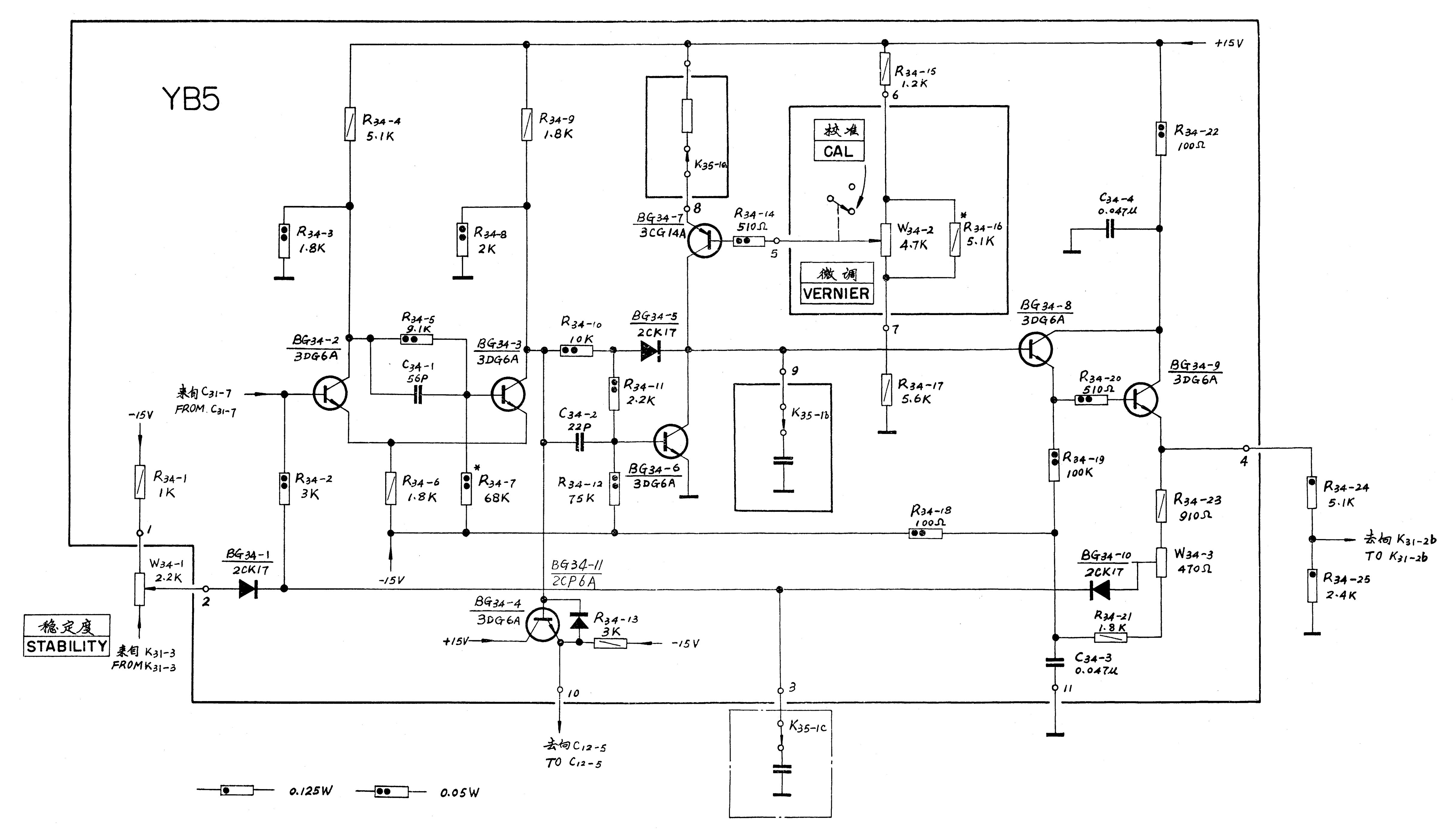
示波管电路和增辉放大电路　C.R.T. and Unblanking Circuits



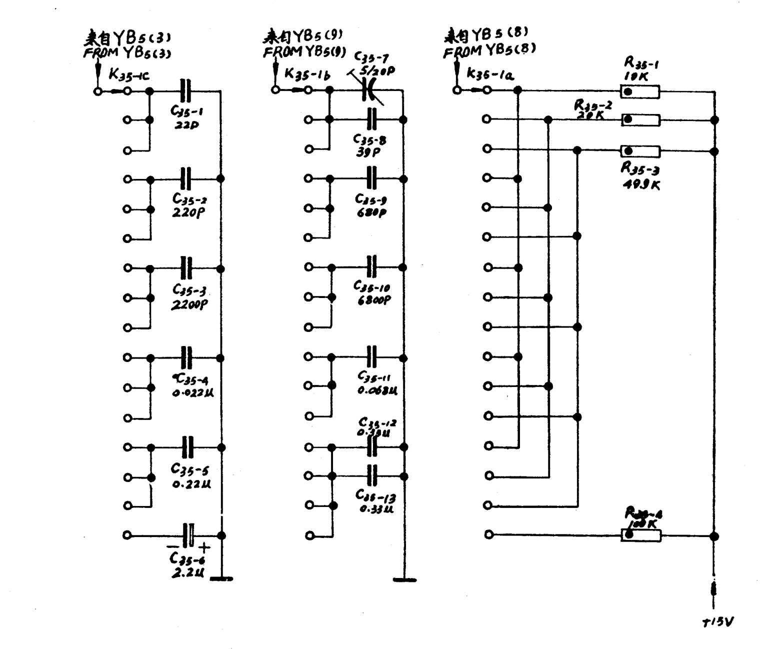
垂直放大器 Vertical Amplifier



触发电路 Trigger Circuit



扫描发生器 Sweep Generator

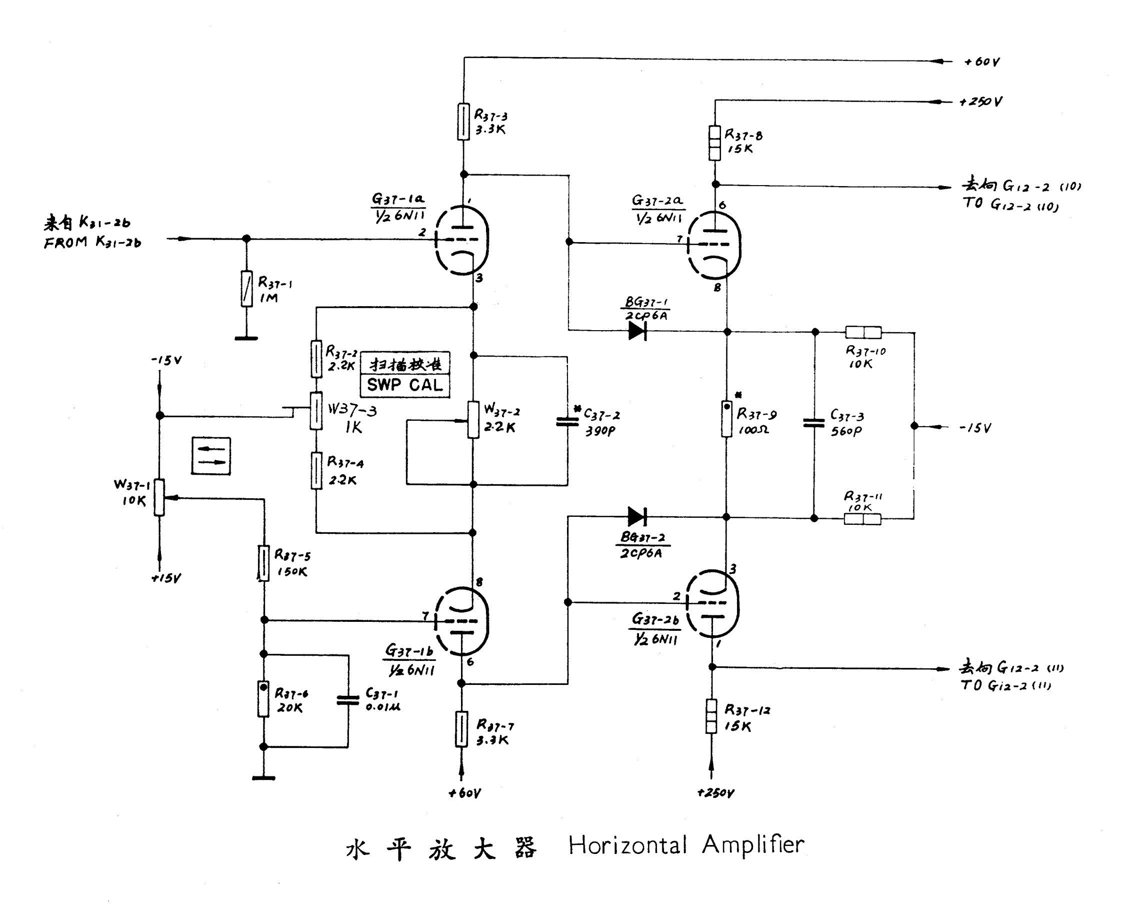


T/div

.1	μs
.2	
.5	
1	
2	
5	
10	
20	
50	
.1	ms
.2	
.5	
1	
2	
5	
10	

0.125W

扫 描 开 关 TIME/DIV Switch



水平放大器 Horizontal Amplifier

零 件 目 录

Parts List

电路记号 Cir. Ref.	说 明 Description	电路记号 Cir. Ref.	说 明 Description
	电阻器 Resistor	R_{22-3}	RJJ—0.125—988K—±1%
R_{02-1}	RJX—0.125—47Ω—II	4	RJJ—0.125-10.1K—±1%
2	RJ—1—51Ω—II	5	RJJ—0.125—1M—±1%
3	RX1—6—820Ω ±5%	6	RTX—0.125—470K—II
4	RX1—10—2.4K—±3%	7	RTX—0.05—100Ω—II
5	RX1—6—7.5K—±5%	8	RTX—0.125—20K—I
6	RTX—0.125—10K—±5%	9	RTX—0.125—910Ω—I
7	RJ—0.5—470Ω—II	10	RTX—0.05—100Ω—II
8	RJ—0.5—2.4K—I	11	RTX—0.125—3.3K—II
9	RTX—0.125—1.5K—II	12	RTX—0.125—3.3K—II
10	RTX—0.125—10K—II	13	RTX—0.125—100Ω—II
11	RTX—0.125—1K—II	14	RTX—0.05—100Ω—II
12	RJ—0.5—82K—I	15	RTX—0.05—100Ω—II
13	TRX—0.125—2.2K—II	16	RTX—0.125—2.2K—II
R_{12-1}	RJ—0.5—1M—II	17	RTX—0.125—2.2K—II
2	RJ—0.5—1K—II	18	RTL-0.125-549Ω-±1%
3	RJ—0.5—150K—II	19	RTL-0.125-301Ω-±1%
4	RJ—0.5—2.2M—II	20	RTL-0.125-165Ω-±1%
5	RJ—1—6.8M—I	21	RTX—0.125—750Ω—I
6	RJ—0.5—1M—II	22	RTX—0.125—750Ω—I
7	RJ—0.5—620Ω—I	23	RTX—0.05—100Ω—II
8	RJ—0.5—36K—I	24	RTX—0.05—100Ω—II
9	RJ—0.5—12K—II	25	RTX—0.125—2.2K—II
10	RJ—0.5—620Ω—I	26	RTX—0.125—2.2K—II
11	RJ—0.5—1M—II	27	RTX—0.05—100Ω—II
12	RJ—0.5—1K—II	28	RTX—0.05—100Ω—II
R_{22-1}	RJJ—0.125—909K—±1%	29	RTX—0.125—20Ω—I
2	RJJ—0.125—111K—±1%	30	RTX—0.05—100Ω—II

电路记号 Cir. Ref.	说明 Description	电路记号 Cir. Ref.	说明 Description
R_{22-31}	RTX—0.125—2.2K—II	R_{31-9}	RJX—0.25—3K—I
32	RTX—0.125—2.2K—II	10	RTX—0.05—100Ω—II
33	RTX—0.125—180Ω—II	11	RTX—0.05—5.1Ω—I
34	RTX—0.125—51Ω—I	12	RJX—0.25—1.5K—II
35	RTX—0.05—100Ω—II	13	RTX—0.05—7.5K—I
36	RTX—0.125—100Ω—II	14	RTX—0.05—56K—II
37	RTX—0.125—3KΩ—I	15	RJX—0.25—1.2K—II
38	RTX—0.125—4.7KΩ—II	16	RJX—0.25—820Ω—II
39	RTX—0.125—4.7KΩ—II	17	RTX—0.05—2.4K—I
40	RTX—0.125—680Ω—II	18	RTX—0.05—10K—II
41	RTX—0.125—680Ω—II	19	RTX—0.05—4.7K—II
42	RTX—0.05—100Ω-II	20	RTX—0.05—12K—II
43	RTX—0.05—100Ω—II	R_{34-1}	RJX—0.25—1K—II
44	RTX—0.125—1.6KΩ—I	2	RTX—0.05—3K—I
45	RTX—0.125—1.6KΩ—I	3	RTX—0.05—1.8K—II
46	RTX—0.125—51Ω—I	4	RJX—0.25—5.1K—I
47	RJX—0.25—300Ω—I	5	RTX—0.05—9.1K--I
48	RT—0.5—8.2KΩ—II	6	RJX—0.25—1.8K—II
49	RT—0.5—2KΩ—I	7	RTX—0.05—68K—II
50	RJ—2—3KΩ—I	8	RTX—0.05—2K—I
51	RJ—2—3KΩ—I	9	RJX—0.25—1.8K—II
52	RJ—0.5—200Ω—I	10	RTX—0.05—10K--II
53	RJ—0.5—200Ω—I	11	RTX—0.05—2.2K—II
R_{31-1}	RJX—0.25—1M—II	12	RTX—0.05—75K—I
2	RJX—0.25—1M—II	13	RJX—0.25—3K—I
3	RTX—0.05—47Ω—II	14	RTX—0.05—510Ω—I
4	RTX—0.05—2.4K—I	15	RJX—0.25—1.2K—II
5	RJX—0.25—3.3K—II	16	RJX—0.25—5.1K—I
6	RTX—0.05—4.7K—II	17	RJX—0.25—5.6K—II
7	RJX—0.25—3K—I	18	RTX—0.05—100Ω—II
8	RTX—0.05—100Ω—II	19	RTX—0.05—100KΩ—II

电路记号 Cir. Ref.	说明 Description	电路记号 Cir. Ref.	说明 Description
R_{34-20}	RTX—0.05—510Ω—I	C_{12-1}	高压混介 0.47 μF2KV
21	RJX—0.25—1.8K—II	2	C404—22000—2KV
22	RTX—0.05—100Ω—II	3	高压混介 0.22 μF2KV
23	RJX—0.25—910Ω—I	4	CY2-1-A-100-68±10%
24	RTX—0.125—5.1K—I	5	CDX—3—C_0—25—30
25	RTX—0.125—2.4K—I	C_{22-1}	CZJX—400—0.1±20%
R_{35-1}	RJJ—0.125—10K±1%	2	CW—D—5
2	RJJ—0.125—20K±1%	3	CW—D—5
3	RJJ—0.125—49.9K±1%	4	CYX-1-A-100-30±5%
4	RJJ—0.125—100K±1%	5	CCXI—U—2.2±10%
R_{37-1}	RJX—0.25—1M—II	6	CW—D—5
2	RJ—0.5—2.2K—I	7	CW—D—5
3	RJ—0.5—3.3K—I	8	CYX-1-D-100-360±5%
4	RJ—0.5—2.2K—I	9	CCX1—C—1000
5	RJ—0.5—150K—II	10	CCX1—C—10000
6	RJX—0.25—20K—I	11	CCX1—C—10000
7	RJ—0.5—3.3K—I	12	CCX1—C—10000
8	RJ—2—15K—II	13	CY2-1-A-100-120±10%
9	RTX—0.125—100Ω—II	14	CCX1—C—10000
10	RJ—1—10K—II	15	CY2-1-A-100-150-±10%
11	RJ—1—10K—II	16	CCX1—C—10000
12	RJ—2—15K—II	17	CCX1—C—10000
	电容器 Capacitr	18	CCX1—C—10000
C_{02-1}	CDZ—$\frac{450-450}{20-20}$—B_0	19	CY2-1-A-100-33-±10%
2	CDZ—$\frac{300-300}{20-20}$—B_0	C_{31-1}	C13—2—63—0.33—III
3	CD—1—Co—50—500	2	CZJ2—160—0.01±20%
4	CDX—3—Co—25—30	3	C1X—2—330±20%
5	CDX—1—C_1—25—100	4	CDX—3—C_0—10—30
6	CD—1—C_0—50—500	5	C1X—2—470±20%
7	CDX—1—C_1—25—100	6	C1X—1—33±20%
8	CDX—3—C_0—10—50	7	C1X—1—33±20%

电路记号 Cir. Ref.	说明 Description	电路记号 Cir. Ref.	说明 Description
C_{31-8}	CCX1—C—10000		20ZS—3
9	CZ3—1—63—0.047—III	W_{22-1}	WH5—1—1W—47K—X—20ZS—3
C_{34-1}	C1X—1—56±20%	2	WH7—B_1—1KΩ
2	C1X—1—22±20%	3	WH9—K_1—1K—X—16ZS—3
3	C13—1—63—0.047—III	4	WH9—2-$\frac{10K}{10K}$-X—20ZS—3
4	C13—1—63—0.047—III	5	WH5—1—1W—470Ω—X-20ZS—3
C_{35-1}	CYX-1-A-100-22±20%	W_{31-1}	WH9-K_1-4.7K-X-20ZS-3
2	CYX-1-8-100-220±20%	W_{34-1}	WH5—1—1W—2.2K—X—20ZS—3
3	CL1—1—63—2200±20%	2	WH9—K_1—4.7K—X—16ZS—3
4	CL1—1—63—0.022±20%	3	WH7—B_1—470Ω
5	CZJ2—1—160—0.22±20%	W_{37-1}	WH5—1—1W—10K—X—20ZS—3
6	CA—25—2.2±20% A	2	WH5—1—1W—2.2K—X—20ZS—3
7	CCWX—4—$^5/_{20}$	3	WH7—A_1—1K
8	CYX-1-A-100-39±20%		电子管 Tube
9	CYX-1-8-100-680±20%	G_{12-1}	1Z1B
10	CL1—1—63—6800±20%		示波管 C.R.T
11	CL1—1—63—0.068±20%	2	8SJ31J
12	CZJ2—1—160—0.33±20%		电子管 Tube
13	CZJ2—1—160—0.33±20%	3	6N11
C_{37-1}	CCX1—C—10000	G_{22-1}	6N11
2	CY2-1-A-100-290±10%	G_{37-1}	6N11
3	CY2-1-A-100-560±10%	2	6N11
	电位器 Potentiometer		晶体管 Transistor
W_{02-1}	WH7—B_1—10K	BG_{02-1A}	03Z8
2	WH5—1—1W—2.2K—X-12ZS—3		
W_{12-1}	WH5—1—1W—2.2M—X-20ZS—3		
2	WH5—1—1W—1M—X—20ZS—3		
3	WH5—1—1W—470K—X-		

电路记号 Cir. Ref.	说明 Description	电路记号 Cir. Ref.	说明 Description
BG_{02-1B}	03Z8	BG_{22-10}	3DG6A
BG_{02-2A}	03Z8	11	3DG8A
2B	03Z8	12	3DG8A
3	3W60	13	2CW3
4	2CP21A	14	2CW3
5	2CP21A	BG_{31-1}	2CK17
6	2CP21A	2	2CK17
7	2CP21A	3	3DJ7
8	3AX31A	4	3DG6A
9	3AD6C	5	3DG6A
10	2CW20	6	3DG6A
11	2CP21A	7	3DG6A
12	2CP21A	8	2AP6
13	2CP21A	9	2CK17
14	2CP21A	BG_{34-1}	2CK17
15	3AD6C	2	3DG6A
16	2CW20	3	3DG6A
17	2DW7A	4	3DG6A
18	3DG6A	5	2CK17
BG_{12-1}	2CP6A	6	3DG6A
2	2CP6A	7	3CG14A
3	2CP6A	8	3DG6A
BG_{22-1}	3DG6A	9	3DG6A
2	3DJ7	10	2CK17
3	3DJ7	BG_{37-1}	2CP6A
4	3DG6A	2	2CP6A
5	3DG6A	3	2CP6A
6	3DG6A	B_{02-1}	电源变压器 Power transformer
7	3DG6A		
8	3DG6A	ZD_{02-1}	小型信号灯 Pilot lamp
9	3DG6A		XDX_1—R

电路记号 Cir. Ref.	说明 Description	电路记号 Cir. Ref.	说明 Description
	保险丝 Fuse	K_{31-1}	KBD—5 3W3D
BX_{02-1}	BGXP 1A	2	KBD—5 3W6D
2	BGXP 1A	3	(附属于 W_{34-1} incorporated in W_{34-1})
3	BGXP 0.5A	K_{35-1}	波段开关 Range switch
4	BGXP 0.5A	CZ_{02-1}	小型三线电源插座 $3CZD_3$ 型 3-wire power socket
	开关 Switch		高频插座 H.F. socket
K_{02-1}	KNX—2W1D	CZ_{22-1}	Q9—50Y
K_{22-1}	KBD—5 3W3D	CZ_{31-1}	Q9—50Y
2	波段开关 Range switch		
	开关 Switch		

装　　箱　　单

品　　名　　及　　种　　类	单　位	数　　量
ST 16 通用示波器	台	1
使用说明书	本	1
探头10:1	根	1
导线(电源)	根	1
保险丝 0.5 A	只	5
保险丝 1 A	只	5
产品检验合格证	份	1

中 华 人 民 共 和 国 制 造

MAINTANENCE RECORD

DATE	
6/11/81	BG20-15 (3DG6A) Replaced With 2SC815 collector – base Junction o/c.
2/1/81	C02-5 C02-7 Replaced with 220μF 25V cap. Preventive!
1/1/84	C31-4 Replaced by 33μF 25V Tantalum.
25/6/87	FUSES BX02-2 (1A) & BX02-4 (0.5A) Replaced BX02-2 with 1A Replaced BX02-4 with 1A (Out of rating. BG31-4 BG31-5 Replaced with 2N2222